"The unanimity with which all those which rise within a certain radius of a given tree crawl in a bee line to the trunk of that tree is most interesting. To witness these pupæ in such vast numbers that one can not step on the ground without crushing several swarming out of their subterranean holes and scrambling over the ground. all converging to the one central, point, and then in a steady stream clambering up the trunk and diverging again on the branches is an experience not readily forgotten and affording good food for speculation on the nature of instinct. The phenomenon is most satisfactorily witnessed where there is a solitary or isolated tree.

The pupæ begin to rise as soon as the sun is hidden behind the horizon, and they continue until by 9 o'oclock the bulk of them have risen. A few stragglers continue until midnight. They instinctively crawl along the horizontal branches after they have ascended the trunk and fasten themselves in any position, but preferably in a horizontal position on the leaves and twigs of the lowermost branches. In about an hour after rising and settling the skin splits down the middle of the thorax from the base of the clypeus to the base of the metanotum, and the forming Cicada begins to issue.

The colors of the forming Cicada are a creamy white, with the exception of the reddish eyes, the two strongly contrasting black patches on the prothorax, a black dash on each of the coxæ and sometimes on the front femora, and an orange tinge at the base of the wings.

There are five marked positions or phases in this act of evolving from the pupa shell, viz., the straight or extended, the hanging or head downward, the clinging or head upward, the flat winged, and finally the roof winged. In about three minutes after the shell splits, the forming imago extends from the rent almost on the same place with the pupa, with all its members straight and still hold by their tips within the exuvium. The imago then gradually bends backward and the members are loosened and separated. With the tip of the abdomen held within the exuvium, the rest of the body hangs extended at right angles from it, and remains in this position from ten to thirty seconds or more, the wing pads separating, and the front pair stretching at right angles from the body and obliquely crossing the hind pair. They then gradually swell, and during all this time the legs are becoming firmer and assuming the ultimate positions Suddenly the imago bends upward with a good deal of effort, and, clinging with its legs to the first object reached, whether leaf, twig or its own shell, withdraws entirely from the exuvium and hangs for the first time with its head up. Now the wings perceptibly swell and expand until they are fully stretched and hang flatly over the back, perfectly transparent with beautiful white veining. As they dry they assume the roofed position, and during the night the natural colors of the species are gradually assumed.

The time required in the transformation varies, and, though for the splitting of the skin and the full stretching of the wings in the flat position the time is usually about twenty minutes, it may be, under precisely similar conditions, five or six times as long. But there are few more beautiful sights than to see this fresh forming Cicada in all the different positions, clinging and clustering in great numbers to the outside lower leaves and branches of a large tree. In the moonlight such a tree looks for all the world as though it were full of beautiful white blossoms in various stages of expansion."

The Process of Egg-Laying.

Shortly after emerging the adults begin the work of egg-laying the real purpose of their brief aerial life of about six weeks. Within two weeks after their appearance, egg slits may be noticed, and rapidly become increasingly abundant. The female is not particularly choice in her selection of plants as repositories for the eggs, as many observers have noticed. A preference, however, seems to be shown for the oak, chestnut and hickory among forest trees, and for the apple and peach among fruit trees. But almost any tree, shrub or even herbaceous plants may be used, it being more a question of availability than anything else, and the most convenient plant is likely to be used. That they are not particularly discriminating may be judged from the fact that, according to Mr. Hunter Nichols, as recorded by Marlatt, the females were seen attempting to oviposit in the iron rod of a bridge. The part of the plant selected is more usually the one, or less usually, two year old wood, as these are

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THE

SIXTEENTH

ANNUAL REPORT

OF THE

MARYLAND

Agricultural Experiment Station,

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H33.00

COLLEGE PARK,

PRINCE GEORGE'S CO., MARYLAND.

1902--1903.

PUBLISHED BY THE STATION.

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THE
Maryland Agricultural Experiment Station.

CORPORATION.
THE BOARD OF TRUSTEES OF THE MARYLAND AGRICULTURAL COLLEGE.

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The Station is Located on the B. & O. R. R. and City & Suburban Electric Car Line, 8 miles north of Washington, D. C.
Bell Telephone—Washington Directory—Hyattsville 42.

Visitors will be welcomed at all times, and will be given every opportunity to inspect the work of the Station in all of its departments.

The Bulletins and reports of the Station, will be mailed regularly, free of charge to all residents of the State who request it.

ADDRESS:

AGRICULTURAL EXPERIMENT STATION,
College Park, Maryland.

LETTER OF TRANSMITTAL.

To His Excellency, John Walter Smith,
Governor, and President of the Board of Trustees,
Annapolis, Md.

Sir:—In accordance with the provisions of Section No. 3, of the Act of Congress, approved March 2, 1887, "To Establish Agricultural Experiment Stations," etc., I have the honor to transmit the Sixteenth Annual Report of the Maryland Experiment Station for the fiscal year ending June 30, 1903.

Very respectfully yours,

H. J. PATTERSON,
Director of the Experiment Station.

July, 1903.

THE MARYLAND
AGRICULTURAL EXPERIMENT STATION.

Volume 16. 1902-1903.

Report on the Work and Expenditures of Maryland Agricultural Experiment Station,

FOR THE YEAR ENDING JUNE 30, 1903.

By H. J. PATTERSON, Director.

Owing to the growing interest in the Experiment Station, by farmers generally throughout the State, and in order to answer some of the numerous requests for general information on the work of the Station, and at the same time to correct some false impressions as to the nature of the work, it has been thought wise to include in this report a brief historical sketch of the Station, its organization and equipment, together with the lines of the work in progress, with some general statements as to the influence which the agricultural investigations are exerting upon the farmer and his business.

HISTORICAL SKETCH.

That there was a necessity for institutions of this character, was manifested early in the fifteenth century in England and Europe, and the first agricultural records in America made it very pronounced that help and information which such institutions might furnish was desired. This was evidenced by the objects set forth in the organization of the first Agricultural Societies. The Agricultural Societies formed in Pennsylvania and South Carolina in 1785 had among their objects the establishment of Experiment Farms, and Washington, in his message to Congress in 1796, advocated the establishment of a National Board of Agriculture, one of the functions of which would be "to encourage and assist a spirit of discovery and improvement by stimulating to enterprise and experiment."

The application of chemical science to agricultural began to attract considerable attention in Europe in 1840, but it remained for Maryland to take the lead of the States in making provision for research of this kind. This was done by the passage of a bill at the December session, 1847, of the Maryland Legislature, making provision for the appointment of a State laboratory.* The bill for this purpose was introduced by S. D. Coad, of St. Mary's County, Chairman of the Committee on Agriculture. The action of Maryland in this respect was frequently referred to by the executives of different States, and the New York Agricultural Society

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NOTE.—By special request part of this matter was prepared and read before the Vansville Farmers' Club, at their regular meetings, and this club sent a resolution to the Board of Trustees, asking that the matter be published and distributed generally to the farmers of the State. The Trustees of the Station complied with the request and ordered this matter published.

followed the example of Maryland and in 1849 established a chemical laboratory for the analysis of manures, soils and plants.

The first act of a State Legislature providing expressly for experimental work in agriculture in America, was embodied in Sec. 6 of the Act to establish and endow an Agricultural College, passed by the Legislature of Maryland in 1856, and which reads as follows:

> "It shall be the duty of the said board of trustees to order and direct to be made and instituted on said model farm, annually, a series of experiments upon the cultivation of cereals and other plants adapted to the latitude and climate of the State of Maryland, and caused to be carefully noticed upon the records of said institution the character of said experiments, the kind of soil upon which they were undertaken, the system of cultivation adopted, the state of atmosphere, and all other particulars which may be necessary to a fair and complete understanding of the result of said experiments."

The records of thè College show that in 1858, immediately after the College was located, and before building began, field experiments with corn, oats and potatoes, "to test the relative values of different manures offered for sale in the cities of Washington and Baltimore," were commenced on the College farm. This work continued for two or three years, but was interrupted by the financial distress which soon affected the whole country and by the disturbed political condition of the State and nation.

These few facts show that early in American history there was a fairly wide demand for information of a definite character on agricultural topics, and this demand kept growing until it gained strength to induce legislatures to recognize that special institutions, or Agricultural Experiment Stations, should be established and provided for at State expense. The first to give this recognition was Connecticut, in 1875; this was followed closely by North Carolina, in 1877; Cornell, in 1879; New Jersey, in 1880; Wisconsin, in 1881; Massachusetts and Ohio, in 1882, and with other additions to the ranks until the establishment of the Hatch Stations in every State and Territory by the National Government in 1887.

The Hatch Act appropriated $15,000 annually to each state for research work in Agriculture and kindred subjects. The Hatch Act did not directly carry an appropriation, so it did not become operative until provided for by the 50th Congress by an appropriation act approved February 2, 1888. The duties imposed by this act are:

> "That it shall be the object and duty of said Experiment Stations to conduct original researches or verity experiments in the physiology of plants and animals; the diseases to which they are severally subject, with the remedies for the same; the chemical composition of useful plants at their different stages of growth, the comparative advantages of rotative cropping as pursued under a varying series of crops; the capacity of new plants or trees for acclimation; the

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* It might be of interest to note that this bill in a measure provides at the same time for the conducting of Farmers' Institutes, as is evidenced by the following:

"SEC. 5. Be it enacted, That it shall also be his further duty to deliver one public lecture, after having given timely notice thereof, in each election district in each county, and then to deliver a course of public lectures at each county town, and at some central place in Baltimore County, having given also sufficient notice thereof in each election district; and he shall permit the clerk of the levy court or the commissioners of the tax, as the case may be, to take a copy of such course of lectures, to be retained and kept for the use and benefit of the county, and published by said levy court or commissioners of the tax, if to them it shall seem expedient."

analysis of soils and waters; the chemical composition of manures natural or artificial, with experiments designed to test their comparative effects on crops of different kinds; the adaptation and value of grasses and forage plants; the composition and digestibility of the different foods for domestic animals; the scientific and economic questions involved in the production of butter and cheese; and such other research s or experiments bearing directly on the agricultural industry of the United States, as may in each case be deemed advisable, having due regard to the varying conditions and needs of the respective States or Territories."

The terms of the Hatch Act were formally assented to and accepted by an act of the Maryland Legislature, approved March 6, 1888, whereby the Maryland Agricultural College was made the beneficiary of this fund. The Experiment Station, by this act became a department of the College, which connection works to the mutual advantage of both institutions. From 1888 to 1892, the president of the College was also director of the Experiment Station, but in 1892 the board of trustees so far separated the Station from the College as to put it under a special director, who has no college duties or connection and who is directly responsible to the Board.

Organization.—The College is a combined State and stockholder institution, and, with its Experiment Station, is governed by a board of seventeen trustees, which consists of the Governor of the State, the President of the Senate, the Speaker of the House of Delegates, the Attorney General, State Treasurer and Comptroller, ex-officio; six members appointed by the Governor of the State, one practical farmer from each congressional district for a term of six years; and five members elected by the stockholders and serving for one year or until their successors are elected. The Governor of the State is, ex-officio president of the board. This entire board of trustees elect the station officers and fix salaries, but all the expenditures are directed by a Station Committee consisting of five members of the board appointed by the governor for a term of one year.

Equipment.—At the present time all the College property, except that occupied by the college buildings and campus, is under the control of the Experiment Station. This provides about 200 acres under cultivation and 60 or 70 acres in woodland, which is available as a run for cattle in connection with the permanent pasture. About 50 acres are devoted to plot experiments and most of the general farm to rotation experiments.

The Buildings of the Station are as follows:

1. The main building which contains the Director's office, general office and mailing room, clerk's office, library, chemical laboratory, and quarters for some of the force; 2. The horticultural building which contains the offices of the horticulturist, agriculturist, and farm superintendent; 3. Green houses and propagation houses; 4. Creamery; 5. Main barn; 6. Feeding Experiment barn; 7. Piggery; 8. Tool shed, corn crib and sheep shed; 9. Large round barn; 10. A round silo 120 capacity and two 60 ton silos; 11. Wagon shed, corn crib, and granary (near the round barn); 12. Air-curing tobacco barn; 13. Flue-curing tobacco barn; 14. Garden-tool house; 15. Besides the accomodations given by the above named buildings, the laboratories of the etomologist, vegetable pathologist and veterinarian are located in the Morrill Science Hall; 16. Quarters for herdsmen and dairy apprentices.

In some cases the equipment of the different divisions is fairly good but in others it is rather meager. In all departments the aim will be to place the best facilities for work which can be devised at the command of the workers as rapidly as the funds of the Station will permit.

LINES OF WORK OF THE STATIONS.

From the section quoted we see the lines of work imposed by the Hatch Act was really limited to investigations and the publication of the results; while the work outlined by the State acts passed before and since the establishment of the Hatch Act has caused the broadening of the Station's work so as to include a great variety of functions. This makes it difficult to classify the work being done, yet it may be conveniently grouped under the following heads;

1. **Investigation involving original features.**
2. **Verification and demonstration experiments.**
3. **Studies of natural agricultural conditions and resources.**
4. **Inspection and control or police work.**

These are the general lines of work being pursued by the Stations of the United States and the Maryland Station with the work of the College in its police control duties can be said to be doing something under each class; yet for better information the following are the more detailed lines of investigation now in progress;

GENERAL AGRICULTURE.

Forage and Hay Crops.—1. Investigations for determining a rotation of soiling crops which will provide an abundance of green roughage for as great a portion of the year as possible and at the same time determining the best means of always having available a combination of leguminous and graminaceous crop.

2. Investigations upon the manners and varieties of corn and cowpeas to grow for silage purposes.

3. General study of Leguminous crops for silage.

4. Investigations upon the growing of Alfalfa.

5. A study of the means for soil inoculation as a requisite for the growth of various legumes.

6. A study has been in progress for several years upon thirty-two varieties of grasses for hay and pasture purposes as to their adaptation to the climatic and soil conditions, productiveness, aggressiveness, longevity, time of seeding, and time of development. This work is now sufficiently advanced so as to make it possible to draw some conclusions. This will be issued in bulletin form at an early date.

Grain Crops.—1. Corn breeding by selection so as to improve the yield and the quality. At this Station we are using three varieties of white corn and four varieties of yellow corn in this work, and we are co-operating with the Maryland Corn Breeders' Association in directing and checking up the work of the individual members. There are seven active members taking part in the breeding.

2. Wheat-breeding by selecting. Some of this work and also cross-breeding is being done in co-operation with the U. S. Dept. of Agriculture. The object in all of this breeding work is to produce varieties which are better adapted to the soils and climate of this region, and to make them more valuable, particularly as to their yielding power, quality, ability to resist disease, and time of maturing.

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3. Methods of manuring, seeding and cultivating corn.

Potato Experiments.—1. System of planting and culture of potatoes.

2. Northern grown vs. second crop seed potatoes.

CHEMICAL DIVISION.

1. Chemical analysis of miscellaneous samples sent for examination.
2. Check and control work in connection with the investigations of other divisions.
3. A continuation of the study of the effects of preservatives upon the digestibility of milk.
4. Study of the relation between the kind of baking powder used and the digestibility of bread.
5. Study of the quality of the corn used for breeding.
6. Investigation of milk substitutes for calf feeding.
7. Beef-feeding experiments.
8. Pig-feeding experiments.
9. Lime experiments.
10. Phosphoric acid experiments.
11. Potash experiments.
12. Nitrogen experiments.

DAIRY DIVISION.

1. A continuation of the study begun last year upon the effects of preservatives upon the digestibility of milk. This investigation was completed and the results reported in Bulletin No. 86.
2. A continuation of the study of the conditions which affect the keeping quality of milk and of the means which are available to farmers for bettering the milk supply. A bulletin on this subject is now in press.
3. The study of the conditions which affect the moisture content of butter has been continued.
4. A continuation of the investigation of means for removing garlic from milk and butter.
5. Some feeding experiments with the dairy herd were planned for the winter, but were not carried out owing to the delay in getting the necessary feeds, due to the congested condition of the freight traffic.

VETERINARY DIVISION.

The absence of cases of Leucoencephalitis in Maryland since the last Annual Report has prevented further studies of that trouble. However, while engaged in other work during the year, a disease of horses was observed that created considerable alarm and was responsible for a number of deaths. The disease in itself was not serious, but on account of deficiency in its treatment, and neglect, some cases became complicated and death resulted. This trouble was diagnosed as contagious stomatitis, and was recognized by an eruption which produced fissures upon the lips and cheeks and an inflamed condition of the tongue. This was probably aggravated by the character of the food, but it usually disappeared within two weeks. In the fatal cases this inflammation extended along the respiratory tract, and death resulted from the complications. In those cases properly treated, but few deaths occurred.

The dairy herd has been retreated for tuberculosis and several animals responded to the test. These animals have been placed with the isolated herd and will be used for further experiments.

The results of the repeated injections of tuberculin into the affected cows cannot be reported as yet, though their general condition would warrant one to assume an improvement has taken place. During the year the Jersey Bull became affected with Cirrhosis of the Liver from the effects of which he finally died. While this represents a considerable loss, it is fortunately the first animal lost with disease, other than those destroyed for tuberculosis, in a number of years.

Although the Veterinary Division is regarded principally as an advisory department, it is hoped that some arrangement can be made whereby funds can be had for an isolated building for the use of this department. This is essential for the progress of this division, and can be used to great advantage.

HORTICULTURAL DIVISION.

The work in the Horticultural Department may be briefly outlined as follows:

1. Improvement of apples.by selecting those better adapted to the soil and climatic conditions of the state, by breeding. A study of the sterility and non-sterility of varieties in Maryland. A survey of the apple industry of the state.
2. Experiments in orchard work, including cover crops, pruning and fertilizers.
3. Continuation of co-operative experiments in the use of cover crops as to their relative value in the different fruit sections of the State.
4. Continuation of co-operative tests as to the relative value of sulphate and muriate of potash upon apples, pears, peaches and cherries.
5. Continuation of a study of the cause of pithiness in celery.
6. A study of cultural methods and varieties of small fruits.
7. Plant breeding and selection of strawberries and carnations.
8. A survey of the strawberry industry of the State, and a study of the types and groups of berries.
9. The testing of novelties in vegetables along by the side of the old standard sorts. Onion growing, cultural methods and variety tests.
10. Best rotation of vegetables for forcing houses and a test of varieties for indoor culture.
11. A study of the adaptability of the different types of plums to Maryland.

Orchards.—There is located upon the Station grounds three orchards, and for convenience in this respect I shall designate them as the Variety Apple Orchard to the east of the Station buildings, the Variety Peach, Pear and Apple Orchard back of the President's house, and the Model Orchard to the south of the college buildings. The Variety Apple Orchard to the east of the Station Buildings was planted in 1888 by Prof. Bishop. While a portion of the orchard has already been removed, it still contains sixteen varieties, and a number of them are showing up very promisingly. I wish especially to speak of Kinnards Choice, this is one of the new varieties of apples of southern origin, and is proving to be a valuable variety for this section of the country. In order to have it become rapidly known and more widely disseminated we have propagated a number of the trees in our small experimental nursery with the view of sending them out to some of the leading fruit men. While the orchard location is not an ideal one in many respects that are considered necessary to apple culture, yet there is a very fair prospect of a bountiful harvest.

During the season of 1902 the orchard was laid off into plots to study the effect of permanent soil in comparison with leguminous and non-leguminous cover crops. The plots are as follows:

Plot 1 is to be kept in permanent sod, the grass to be mowed and go back upon the ground as a mulch.

Plot 2 is to be plowed early in the spring and kept thoroughly cultivated, so as to maintain a dust mulch over the surface until the first to the middle of July, and then seeded to a cover crop of crimson clover.

Plot 3 is to be treated the same as plot 2, except that cowpeas are to be used as the cover crop.

Plot 4 is to be plowed early in the spring, thoroughly harrowed and as soon as possible seeded to cowpeas, and these when nearly ripe are to be plowed under and plot sown to rye, the rye plowed under the following spring and same repeated. The idea here is to keep this plot in some form of cover crop both summer and winter.

Plot 5 the same as plots 2 and 3, except it is sown to rye in the fall as a cover crop.

The variety orchard to the back of the President's was planted in the spring of 1899, and consists principally of some of the newer varieties of apples for both family use and commercial growing. This orchard has not come into bearing enough to give any satisfactory results of the varieties planted there. The orchard was very severely injured by the cicada during the past season.

The model orchard to the south of the College buildings was planted in 1902. It is an orchard of peaches alternated with apples, showing the method of double planting. This orchard is of standard varieties, and is designed for practical work with students, and for experimental work when a number of trees of the same kind is demanded, such as pruning, spraying, thinning, etc.

During the present year a new plum orchard has been started, consisting of eight groups and seventy-six varieties, of the Japan, Hybrid and American types. This orchard was planted for the study of the value of the different types and groups in Maryland, and within a few years ought to give us some very valuable results.

A number of the newer varieties of peaches and apples were planted this season. Varieties were selected that have been successful in other fruit sections having about the same climatic conditions as here.

Small Fruits.—A plot of the leading varieties of currants, gooseberries and raspberries was started in 1902, and this was continued the present season by also planting a number more of the prominent varieties of both red and black raspberries and a large number of the leading varieties of blackberries and dewberries. This plot of small fruits was started to make a careful study of varieties and cultural methods of these fruits.

Strawberries.—The testing of varieties of strawberries has always been an important line of work of this Station. The plantation for fruiting this season consists of about seventy-five of the newer and more promising varieties. We have also set out a new trial bed of the leading sorts sent out this season. Some interesting experiments are under way with different material used for mulching strawberry beds during the winter, and the application of fertilizer to the present crop at different times during the spring.

Vegetables.—The work for the past season was a continuation of the lines that have been under way for several years. The principal lines have been variety testing, fertilizer tests with cabbage, and an investigation of the cause of pithiness of celery. With the fertilizer test with cabbage the question of early and late plowing was studied as to the effect of the application of fertilizers to the plot when plowed early in comparison to its effect when applied to plots at planting time. This same experiment will be duplicated again this season.

In the experiments for causes of pithiness of celery the results of the past season only help to strengthen the results as given in the preliminary report in Bulletin No. 83. The work of the present season will be a continuation of practically the same line with the exception of using only one variety of seed, the Golden Self Blanching, instead of two or three as was used the past season. It was our aim to collect from as many of the leading seed firms as possible their seed of both American and European grown, also the seed from the leading Euproean firms for comparative test.

The vegetable work of the present season has been to collect a number of the trade novelties, that is, new varieties of vegetables that have been strongly advertised by the leading seed firms with the claim that they are superior to what we already have, and place these new vegetables by the side of our old standard sorts in our trial plots. We are also giving a good deal of attention to the growing of onions from seed in the open ground in comparison to seed grown in the hot beds and then transplanted into the open field.

In the forcing house the work has been along the same line that has been followed for several years, a study of the best varieties of vegetables for a rotation of crops in green houses; the forcing of carnations upon benches and solid beds, and the best time to set plants in permanent beds; the forcing of tomatoes upon benches and solid beds, and the proper distance for setting the plants.

The co-operative work in the State has been a continuation of work already started by my predecessor. It consists of a study of the effects of sulphate of potash in comparison with muriate of potash upon the peach, apple, pear and cherry of cover crops for orchards. These cooperative experiments were started in 1902 and will have to be continued a long number of years before any definite results can be obtained. The potash salts were used at the rate of 200 pounds per acre. The experiments are located in the State as follows; In Western Maryland, in the apple orchard of Mr. S. S. Stouffer, Sharpsburg and in the peach orchard of Mr. Cabel Long, Boonsboro. Upon the Eastern Shore we have the experiments in the pear, cherry, and apple orchard of Mr. James S. Harris, Colemans, Md.

Co-operative Cover Crop Work.—This line of work was undertaken during 1902, in the then leading fruit sections of the State. The material for the experiments consisted in the main of cowpeas, one and one-half bushel per acre, hairy vetch, one bushel per acre, cowpeas one-half bushel and hairy vetch one-half bushel mixed together per acre, and crimson clover 20 pounds per acre.

In Western Maryland there is one set of the experiments in the apple orchard of Mr. S. S. Stouffer, Sharpsburg, in the peach orchards of Mr. Henry Miller, Sharpsburg and Mr. Cabel Long, Boonsboro. On account of the long drought in that section lasting from about the first of July well into September the seed did not germinate and grow so as to give any satisfactory results. While the crop was not a total failure, no definite comparison could be made between the different seeds.

In Southern Maryland a set of the experiments was upon the peach orchard of Mr. John Snowden, Bowie, Md. At this place the crimson clover gave excellent results, the cowpeas made only fair growth, while the hairy vetch was almost a total failure.

Upon the Eastern Shore in the orchards of Mr. James S. Harris, Colemans, Md., there was one acre of the above seed in the peach and apple orchard and alsike clovers gave the best of results forming a thick heavy cover over the whole surface of the ground. The cowpeas and hairy vetch were almost a total failure.

For the present season we have already planned to extend the work still more by reaching other sections of the State.

This kind of work meets with the hearty approval of the State and we wish to express our appreciation of the careful and painstaking way in which they have aided us in carrying along this important work for the improvement of the orchard conditions of the State.

For further work in the State we have taken up the study of some of the leading fruits and the conditions that make them so promising; during the early part of the year a study of the strawberry by making a survey of the industry of the state, and an investigation of the types and groups of berries, and during the latter part of the year a study of the apple industry and the improving of it by the introduction of varieties better adapted to the soil and climatic conditions of the State. Along the above line we have during the past winter added a number of the leading varieties, and obtained scions of a large number more.

There are many other lines of Horticultural investigation that could be conducted to better advantage in different parts of the State as the land and condition on the Station Farm are typical of only a comparatively small area. This policy of co-operation and outlying experiments will be extended as rapidly as the funds at our disposal will permit.

DIVISION OF BOTANY AND PLANT PATHOLOGY.

The botanist has been able to add considerably to the knowledge of wild plants (weeds, fungi, woods, grasses, etc.) of Maryland when traveling in connection with the State Inspection work, but finds little time to spend on this of itself. Several hundred specimens picked up on these trips have been added to our collection. No flora of the State has ever been published, but we now have material at hand for a fairly good list of Maryland plants.

Frequent inquiries referred to the office, regarding the name and nature of various wild plants, weeds, grasses, etc., have been investigated and answered. The sending of such specimens of weeds, diseases, etc., for our collection has been encouraged. It is hoped that some time a work on the weeds of the State can be prepared.

A number of samples of seeds have been tested for germination and examined for weed seeds or adulteration. The importance of pure seed is shown by a recent case where a field was sown to white mustard supposed to be crimson clover. Dodder seed is often mixed with alfalfa or clover and is not readily distinguished.

Several letters regarding the culture of ginseng in Western Maryland have been answered, and several inquiries about poisonous plants have been investigated.

Inspection.—Fifty-six nurseries have been inspected for yellows, fire blight, black knot and crown gall. Other less dangerous diseases are also noted. The usual conditions prevail with regard to diseases in nurseries, except that certain root diseases seem to be coming more abundant. About 1,800 orchards or premises were inspected during the summer and fall of 1902. Most of the inspection work of this department has been concerned with peach yellows. The importance of this disease in Maryland above the diseases of other trees is indicated by the fact that the 1,800 orchards examined contained four times as many peach trees as all other trees combined. Over 1,090,000 peach trees were inspected this year. Less than 1 per cent. of these was found diseased with yellows. The per cent. of yellows in affected regions is 1.3. In the larger, well-kept orchards, the per cent. is only .35, while in the smaller orchards it is 1.5. In regions where no effort is taken to keep the disease in check, the peach has practically disappeared.

Investigations on Plant Diseases.—1. A study of the distribution and extent of all important diseases of cultivated plants in Maryland was prepared during the past year from personal collections and notes from all parts of the State and from correspondence with prominent horticulturists. This was published in the Fifth Annual Report of the Maryland State Horticultural Society.

2. The distribution and extent of yellows has had special attention. (See Inspection.) A search has been made for resistant forms. The disease has not been found to any extent beyond the southern limit of ten years ago.

3. Co-operative experiments in the use of Bordeaux mixture to prevent cantaloupe blight were conducted with several growers and showed the efficiency of this spray. This is to be continued this summer:

4. Experiments were conducted in two Western Maryland orchards and one in Southern Maryland, in using Bordeaux mixture with a large excess of lime for peach rot, black spot, and other diseases. During the last season all orchards were almost entirely free from rot, but black spot, which developed abundantly in late summer, was almost entirely prevented on the trees sprayed in June. This spray caused very slight injury to the foliage in some cases.

5. The sclerotinia stage of the peach rot fungus was found in the spring of 1902, its life history investigated, and a technical account published in "Science" and in "The Transactions of the Academy of Science

of St Louis." This stage occured again in great abundance this year in Maryland orchards, arising from the mummy fruits of 1901, and has been followed by twig blight in peach and plum. The discovery of this stage shows the importance of destroying the rotten fruits, and of early spraying to prevent the development of the asco spores on the young twigs and blossoms.

6. A study of the nature, distribution in the United States, and injury caused by crown gall on apple has been made with special reference to controlling it in nurseries.

7. The use of various fungicides in controlling the mildew of cabbage has been tested in co-operation with Mr. Richard Vincent, Jr. The best results yet obtained, though not satisfactory, were spraying with Bordeaux mixture, forcing with fertilizers, and keeping leaves and soil surface dry as possible.

8. Investigations on the smut of early corn are in preparation, and several other diseases are under special observation.

DIVISION OF ETOMOLOGY.

As is known, much time of the officers of the Department is taken up with the inspections necessitated by the State Horticultural Inspection Law. In all, fifty-six nurseries have been inspected and forty-five certificates granted. The restriction of the distribution of infested plants has received careful attention, and we have had but few cases reported where infested stock has been shipped out of the State. We have, on the other hand, had to burn several shipments of nursery stock shipped in from other States without certificates and infested with scale. Such cases, however, are comparatively infrequent, and most nurserymen throughout the country at large willingly meet the requirements of the law.

It may be well in this connection to give a synopsis of the inspection work done under this department during the past year.

SYNOPSIS OF INSPECTION WORK DURING 1902.

(Tabulated by A. L. Quaintance.)

County.	No. peach trees inspected.	No. apple trees inspected.	No. pear trees inspected.	No. miscellaneous varieties inspected (quince, cherry, etc.).	No trees found infested with San Jose scale.	No. premises or orchards inspected.	No. premises or orchards found free from San Jose scale.
Anne Arundel.....	106,175	8,100	5,005	530	12,797	107	36
Baltimore	31,000	11,800	8,700	....	4,885	111	95
Calvert..................	23,300	85	25	50	620	17	7
Caroline	85,750	8,540	11,855	4.485	2,113	238	238
Cecil	....	....	....	1,600	400	21	17
Dorchester............	97,725	31,659	990	....	5,485	325	226
Frederick	43,053	2,607	595	895	2,372	296	171
Kent........................	161.175	535	49,925	292	13,796	116	50
Montgomery	750	800	....	....	50	10	7
Prince George.....	....	....	....	332	....	9	9
Queen Anne........	23,750	50	1,160	20	1,070	16	10
Somerset...............	24,000	4,600	5.900	4.220	495	78	55
Talbot	12,565	1,710	600	390	1,193	37	15
Washington	479,495	59,655	9,715	8,283	101,029	513	131
Wicomico.............	2.000	600	400	85	2,400	10	1
Total............	1.090.738	130,141	94.870	20.892	147.704	1 814	1.062

From the above it will be seen that a total of 1,336,731 trees were inspected. Out of this number 147,704 were found infested with the San Jose scale. This is approximately 11 per cent. of the total number of trees examined. It is evident, however, that an equal amount of scale is present on the territory that has not been inspected, and it is our purpose this year to have as much of this territory inspected as possible. The majority of these trees were inspected by our local inspectors, and it is to be hoped that sufficient funds in the future will be provided for the constant employment of a properly qualified inspector for each county of the State. The inspector comes in contact with the grower by visiting his place and explaining the importance of giving his orchard attention. There is thus a diffusion of information among the orchardists, and it is safe to say that with the remedies at hand the progressive orchardists need not fear the San Jose scale in the future as in the past.

Extensive experiments have been conducted during the past year with insecticides against the San Jose scale, as there was much need of a treatment that would be safe, cheap and effective. A detailed account of these experiments will be published at a later date. The tests included the use of kerosene, crude petroleum, whale-oil soap, resin wash, Oregon wash, and lime, sulphur and salt wash. These have been tested in Western Maryland, Southern Maryland and on the Eastern Shore, so that we can compare the results from the various sections of the State. It might be well to state here, however, that we found the lime, sulphur and salt wash to be the most satisfactory remedy sprayed on the trees shortly before the buds begin to swell in the spring. The following experiments are in progress this spring, namely: Testing the insecticidal effect of tobacco dust against the wooly aphis and the black peach aphis; testing the dusting method as against the spraying, for the coddling moth; applying carbon bi-sulphide and various spray mixtures against the melon plant louse; and testing various strengths of Paris green, containing known amount of free arsenious oxid in the foliage of apple, pear, peach and plum. This latter experiment is co-operative with the Department of Agriculture.

Much time was also taken up with correspondence, which was very large; instruction in the college, and in collecting and arranging an economic collection of insects to be exhibited at the county fairs this summer and fall. On the whole, there is an increased interest in the subject of injurious insects and their control; but there are many parts of the State which need awakening to the conditions which exist.

CO-OPERATIVE EXPERIMENTS.

The policy of the Station for a number of years has been to co-operate with farmers in all sections of the State in conducting investigations on a variety of subjects. The general plan pursued has been to solve questions of local interest, and whenever the conditions at the Experiment Station were not such as was necessary or desirable for the proper studying of a given question, then the aim has been to go to that point in the State where the most suitable conditions for making a proper experiment could be obtained.

The farmers of the State have been, in most cases, very generous and have given hearty co-operation in this class of work.

These experiments not only enabled the Station to procure better and more far-reaching results, but they have also excited local interest in this institution that has been healthful and helpful.

It would be well to extend this class of work as much as time and money will permit wherever there is a demand for such help.

Besides the numerous co-operative tests in progress in different parts of the State, this Station is also co-operating with the United States Department of Agriculture whenever such co-operation will be mutually advantageous.

THE WORK OF THE EXPERIMENT STATION FOR THE FARMER.

The investigations in progress at present may mean much to our future agriculture, and in order that we may fully appreciate the far-reaching value of such work let me call to your attention for a few moments a few figures that will serve to impress this more forcibly upon your minds. We have in progress work on breeding up the principal varieties of wheat to make them better adapted to Maryland soils and climate. This work, with the work on classifying soils, should be the means of bringing the average yield up to a profitable basis; but even though it would result in raising the average only one bushel per acre, it would mean over $400,000 annually to Maryland farmers, or nearly $10 per farm. The work on corn improvement needs to be but slight to make a vast difference when applied on the 650,000 acres devoted to this crop in the State. The work in progress, in the study of hay and pasture grasses, will, if applied, increase the value of the products fully five dollars per acre, and when this is done on the 375,000 acres devoted to this class of crops, would be equivalent to nearly $50 per farm; and, furthermore, these investigations should result in making many barren wastes and hillsides profitable that are now not only an eyesore but a burden to the farm. The investigations on animals and animal products will certainly do something in increasing the profits of our 150,000 head of cows, 100,000 steer, 320,000 swine, 200,000 sheep and two and a quarter million head of poultry. The horticultural investigations as to varieties, cultural methods, pruning, thinning, and control of insects and diseases will certainly contribute toward increasing the profits of the 100,000 acres of vegetables, 20,000 acres of small fruits and 100,000 acres of orchard fruits.

These few facts will bring to your minds the great variety of interests of the State, and when you think of the variations in conditions that prevail from the sea level to the three-thousand-feet elevations in the western part of the State, you can realize the amount of opportunities for work that confronts our Station. All could not be done at once, even with unlimited means, but increased facilities and income would hasten many useful investigations.

VALUE OF THE PAST WORK OF THE STATIONS.

We have already shown that there always has been a widespread demand for knowledge on agricultural subjects, and the fact that the demand has grown and produced the agencies for acquiring this knowledge in increased numbers and with enlarged facilities, would seem in itself sufficient evidence that the institutions inaugurated for acquiring the information had been a success, and were not only meriting the confidence but also the material support of the agricultural masses.

In discussing a topic of this nature we must be ever mindful of the fact that there is no fixed rule or measure for valuing the results of such work, and consequently it is hard to give concrete conclusions and examples. In estimating the value of the station work, we must also be mindful of the fact that it is only the function of the station to acquire the knowledge and point out its application; then it remains for the farmer to apply that information to his business, and the results only become remunerative and acquire commercial importance by being utilized. Nevertheless, the truth acquired may be just as great before as after its application, and no doubt many valuable results are slumbering and are unrecognized today because they have fallen on barren soil. At best the results of station work will be applied only by the few and will extend to the many, on the principle that "a little leaven leaveneth the whole;" and this condition permits many a farmer to reap the results of station work who not only does not know where the idea he is using came from, but *frequently sneers* at the Experiment Station and all connected with it.

Before taking up in detail what the Maryland Station has accomplished, it will be best to consider the work of the stations at large, and note a few of the most marked results accomplished by our colleagues, and which are influencing the agriculture of this State as well as that of the particular State in which they were obtained. Prominent among the results of this class may be mentioned the work of the Connecticut Station on the value of the legumes as gatherers of nitrogen and increasers of soil fertilility; the work of Connecticut, Massachusetts, New Jersey and Ohio Stations, on the home-mixing of fertilizers and the special need of some soils for certain plant foods; the work of Illinois, Indiana and Ohio, on showing the superiority of shallow over deep cultivation of corn; the work of Delaware, as to the value of crimson clover as a cover crop; the work of Wisconsin and New York, on the value of silage as a factor in cheapening the production of milk. The Babcock milk test given by Wisconsin has had a marked influence in determining the profitable and unprofitable cow.

The Experiment Stations of the United States are costing about one and a quarter millions of dollars annually; yet I believe any one of the above-mentioned results, if fully applied, would be worth annually several times as much to our agriculture.

Now, in presenting a few facts with reference to our own Experiment Station, you must pardon me if some things which I may say have the savor of "blowing our own horn" and also be somewhat egotistical. Let us consider for a moment a few agricultural statistics of our State, as they will help to a consideration of some phases of this subject in a better light.

The census of June 1, 1900, gives Maryland 46,000 farms, with a total value of farm property of about two hundred and five millions of dollars, and the gross annual sales from these farms was over thirty-five million dollars. Now, this would mean that the national government is spending (for the State of Maryland up to October last had never spent one dollar on the Experiment Station) only thirty-two and one-half cents per farm, or about one dollar for each $2,300 worth of farm products sold. Again, statistics show that the gross annual sales of farm products increased over seventeen million dollars from 1890 to 1900, while it decreased the previous ten years. This increase corresponds with the first ten years of the Station's existence, and, while it is not claimed that the stations were wholly responsible for the changed condition, yet I do believe that the advanced ideas and agricultural awakening of the period was in a measure due to the influence being exerted and the information contributed by the Experiment Stations.

Now for a few moments as to results contributed particularly by our own Station, and for convenience we will discuss them under the heads named above.

1. *Investigations Involving Original Features.*—Under this class we might mention the research upon the physical makeup of the soil, as it is probably having a wider application today than any other, and though now having grown beyond us and passed to the United States Department, yet it was first worked out under our Station auspices, and we are still reaping new matter from the seed sown. The physical and chemical characteristics, as developed by this soil work, only needs to be applied intelligently to contribute many times its cost. Take, for example, the soil survey bulletin of our own county. This gives in detail the physical and chemical character of each class of soils in the county, and maps that part of the county in which they are located. This, with the directions given, will enable a farmer to handle the soils of the county more intelligently and also enable a man to select a farm for a particular purpose. This soil map, with the Bulletin, is worth many times its cost as an advertising medium alone, if properly used by the emigration bureau. An application of the information in the soil survey bulletin of Prince George's county alone would give increased returns that would support our Station, and it would only require five cents per acre to do it.

Our work with methods for the utilization of the corn fodder of the State, I believe, is now annually benefitting the farmers several times the amount the Station costs each year, and if fully utilized, would increase the value of the corn crop of this State at least one dollar per acre, and this would be equivalent to $600,000 per year to our agricultural products. In saying this I do not believe I am overestimating, for recently a farmer in Calvert county said Bulletins Nos. 20 and 41 had increased the feeding capacity of his fodder 33 per cent., and the first year a farmer in Charles county adopted shredding fodder he said that it had enabled him to increase his stock and sell $168 worth of hay where before he always had bought hay.

The new ideas set forth in our Bulletin No. 69, on changing the individuality of cows by care and feed, would result in more than doubling the butter capacity of Maryland's cows, and this would mean at least one million dollars annually.

The investigations on the food value of milk should be of inestimable value to consumers, and by producers following suggestions given they would increase consumption and thus give themselves increased opportunities in dairy farming.

The investigations on celery blight and hollow stalk will be worth to the growers of celery many times the money that has been spent on all our truck crop investigations.

The investigations on growing protein on the farm have shown that the growing of corn and cowpeas in combination can increase the yield of silage three tons per acre and improve the quality 25 per cent.

Our investigations on hog-feeding, if adopted, would cheapen the cost of production of our pork at least 10 per cent., and this would mean over $100,000 per year.

The investigations on lime have placed the subject within reach of those at a distance from sources of lime.

The work on the study of the effects of fertilizers on tobacco will do much toward maintaining the quality of the Maryland product and aid in retaining a market for the same.

The results of the use of insoluble phosphates, while slumbering more or less at present awaiting converts and additions to its ranks, are bound to come to the front and save the money that is now being spent for sulphuric acid and the expenses attending the treating of rock with the same.

2. *Verification and Demonstration Experiments.*—Under this class the work of our Station has been quite extended, the most prominent of which are as follows:

Testing of varieties, culture methods, fertilizers and markets for strawberries. On pointing out improved methods and places to market in one section of our own county, the people are now shipping berries by the carload, where ten years ago they were shipping none, and they are now getting three cents per quart more than they did for the few crates hauled to local markets. The work on varieties of wheat; fertilization of the same has contributed towards the increased acreage yield of this crop.

The demonstrations of the use of spraying to prevent blight in tomatoes have been worth many dollars to the canning industry of this State.

The same can be said of the spraying of peaches, plums, apples and all classes of fruits.

The work of the Entomologist in the control of insects, particularly the scale, is proving a very valuable aid to orchardists, and will enable them to save and protect thousands of dollars now invested in this industry and make the investments profitable. The real value of this class of work can hardly be estimated.

The demonstrations with the feeding of beef and dairy stock have been adopted by many with much pecuniary advantage. One dairyman, by following the ideas suggested by our work, has stated many times that it has increased his sales $300 to $500 per year and lessened his expense. Another stated that the information gained had enabled him to double his butter sales.

Much more might be said on this phase of our work, but sufficient has already been said to show that its value exceeds the expenses incurred.

3. There has not been a great deal done on the investigation of the natural agricultural resources aside from the study of the soil, a work already mentioned, except a study of the agricultural value of the lime and marl deposits of the State.

4. *Inspection and Control, or Police Work.*—This part of the work in Maryland has not been placed directly under the Experiment Station, but has been prosecuted by the College, and the farmers have had the benefit of its results.

The fertilizer control has improved the quality of commercial fertilizers on sale, and while before its inauguration a large per cent. were below guarantee, now it is seldom that a sample falls below. This condition would mean many times the cost of this work to the farmers. What the fertilizer control has done the cattle food control will do in its relative proportion.

The nursery inspection law, while doing much for the nurseryman in keeping his stock in a condition to market it, has also been of inestimable value to the farmer and fruit grower, and its value will become more apparent with advancing years. Besides this prevention of fraud by the regular system of inspection provided for by State laws, the Station has done much useful work of this nature in other directions, such as the testing of varieties of fruits, vegetables, grasses, etc., and shown how extravagant have been the claims of the originators. The test of the purity and vitality of seeds, while not carried out systematically, yet has been of great advantage to farmers.

5. *Dissemination of Information.*—The Station endeavors to bring the results of its work promptly before the people in every way possible. The means which are used are: 1. Bulletins; 2. Correspondence; 3. Station officers giving lectures and talks before farmers' institutes, clubs, granges and other meetings of an agricultural nature; 4. By showing and explaining the work in progress to visitors; 5. By making exhibits at county fairs, etc.

Some of our Bulletins for the dissemination of information, I am sure, have been of a great deal of value to farmers; for example, the Bulletin on the general control of insects and plant diseases, Method for Treatment of Milk Fever, The Dehorning of Stock, and Alfalfa.

While the Experiment Station was organized for the purpose of conducting investigations, yet the farmers look upon it, to a great extent, as a bureau of information, and consequently are continually writing or coming to the Station for help of every conceivable character pertaining to agriculture and things that might bring pecuniary advantage to them, even though many times they are not of an agricultural nature. *This class of work, if paid for on the basis of charges made by the legal or medical profession, would support the Station handsomely.*

Taking all the work done by the Station in dissemination of existing information would seem to me a sufficient reason for the support of such institutions, even though they did nothing in acquiring knowledge.

The demand for Station officers to attend farmers' meetings of various kinds and give addresses on topics relating to agriculture and horticulture, is constantly increasing. This is an important field for work and has been the means of bringing the farmers and the Station close together. Nevertheless, the time consumed in attending such meetings has drawn heavily upon the time of many officers and broken in upon the home duties in some cases to a serious extent and thus lessening the amount of investigations which could be conducted. If all the demands for speakers and requests for special help by making visits to individual farms were met, it would require the whole time of more than one man, and also necessitate a considerable amount for traveling expenses. Sooner or later some special provisions will be required to take care of this class of demands upon the Station and College. Probably the easiest solution of the question would be the enlarging of the functions and facilities of the Department of Farmers' Institutes.

PUBLICATIONS.

So far the Station has published 89 regular bulletins, 11 special bulletins, lettered from A to K (the issuing of this lettered series has been discontinued), and 15 annual reports. The special bulletins were confined mainly to reports of analyses of commercial fertilizers by the State Control, but since 1898 this matter has been published in the Agricultural College Quarterly. The first four annual reports contained the results of many experiments not published in any other way. Annual reports 5 to 11 contained only matter of an administrative character. The annual report at present, beginning with No. 12, is issued in a limited edition, and consists of an administrative document, to which are appended the bulletins published during the year.

The regular bulletins are issued to the regular mailing list, which contains 12,500 names. There are also special mailing lists, covering the following subjects: Creameries and Creamery Patrons, Milk Shippers, Home Dairy Interests, Tobacco Growers, Fruit Growers, Truck Farmers, Florists, Nurserymen, and general horticultural interests. These mailing lists are kept for reference by the card index system, but printed for mailing with a Dick Mailer. It is regretted that a larger percentage of the farmers of the State do not have interest enough in agricultural advancement to have their names placed on the regular mailing list. We should be glad to reach each of the 46,000 farms of the State, but this is more than can reasonably be expected; yet there should be at least one interested farmer receiving mail at every postoffice in the State, but there are postoffices to which we send no bulletins.

The following is a List of Publications issued up to this time:

Publication.	Title.	Author.
1888		
Bulletin 1	History, Organization and Work of the Station	H. E. Alvord
“ 2	Cutting Seed Potatoes for Planting	Do.
“ 3	Fodder Corn and Fodder Cane.	Do.
Annual Report	First Annual Report, 1888	
1889		
Bulletin 4	Experiment Orchards	W. H. Bishop.
“ 5	Horticultural Department and Field Experiments	H. E. Alvord.
“ 6	Commercial Fertilizers	H. E. Alvord and H. J. Patterson.
“ 7	Farm Manures	H. E. Alvord.
Spec'l Bul. A	Facts About the Station	Do.
Annual Report	Second Annual Report, 1889	
1890		
Bulletin 8	Some Feeding Trials	A. I. Hayward.
“ 9	Strawberries: Variety, Comparisons, etc. 1890	W. H. Bishop.
“ 10	Wheat: Effects of Different Fertilizers.	A. I. Hayward.
“ 11	Tomatoes in 1890	W. H. Bishop and H. J. Patterson.
Spec'l Bul. B	Potash and Paying Crops	H. E. Alvord and J. D. Hird.
Spec'l Bul. C	Composition of Commercial Fertilizers Sold in the State	H. E. Alvord.
Annual Report	Third Annual Report, 1890	

Publication.	Title.	Author.
1891		
Bulletin 12	Pig Feeding	H. E. Alvord and A. I. Hayward.
" 13	Strawberries, Season of 1891	J. S. Robinson.
" 14	Wheat Season of 1891	A. I. Hayward.
" 15	The Experiment Vineyard	T. L. Brunk.
Spec'l Bul. D	Composition of Commercial Fertilizers Sold in the State	H. E. Alvord.
Spec'l Bul. E	Composition of Commercial Fertilizers Sold in the State	Do.
Annual Report	Fourth Annual Report, 1891	
1892		
Bulletin 16	Wheat Insects	E. W. Doran.
" 17	Strawberries and Seed Potatoes	J. S. Robinson.
" 18	Sweet Potatoes	E. H. Brinkley.
" 19	Tomatoes	J. S. Robinson.
Spec'l Bul. F	Agricultural Outlook for Maryland	E. Stake.
Spec'l Bul. G	Commercial Fertilizers	H. E. Alvord.
Spec'l Bul. H	Government Direction of Agriculture in Europe	J. E. Ray, Jr.
Spec'l Bul. I	Commercial Fertilizers	
Annual Report	Fifth Annual Report, 1892	
1893		
Bulletin 20	The Composition and Digestibility of Different Parts of Corn Fodder	H. J. Patterson.
" 21	Soils of Maryland	M. Whitney.
" 22	Steer Feeding: Well-Balanced vs. Poorly-Balanced Ration	R. H. Miller.
" 23	Injurious Insects of Maryland	C. V. Riley.
Spec. Buls. J,K	Commercial Fertilizers	H. B. McDonnell.
Annual Report	Sixth Annual Report, 1893	
1894		
Bulletin 24	Composition of Commercial Fertilizers Sold in the State	H. B McDonnell.
" 25	Corn, Potatoes, Tomatoes, Strawberries, Grapes, etc	R. H. Miller and E. H. Brinkley.
" 26	Tobacco	H. J. Patterson.
" 27	Composition of Commercial Fertilizers Sold in the State	H. B. McDonnell et al.
" 28	Experiments with Wheat and Barley	R. H. Miller and E. H. Brinkley.
" 29	Further Investigations on the Soils of Maryland	M. Whitney and S. Key.
Annual Report	Seventh Annual Report, 1894	
1895		
Bulletin 30	Composition of Commercial Fertilizers Sold in the State; The Fertilizer Law; Appendix; Table for Calculating; Fertilizer Analyses and Valuations	H. B. McDonnell et al.
" 31	Potato Experiments	R. H. Miller and E. H. Brinkley.
" 32	San Jose Scale	C. V. Riley.
" 33	Small Fruits, Vegetables and Field Corn	J. S. Robinson.
" 34	Composition of Commercial Fertilizers Sold in the State	H. B. McDonnell et al.
" 35	Wheat, Barley, Oats and Hay Experiments	R. H. Miller and E. H. Brinkley.

Publication.	Title.	Author.
Bulletin 36	Steer-Feeding: A Well-Balanced vs. a Poorly Balanced Ration..................	R. H. Miller and E. H. Brinkley.
Annual Report 1896	Eighth Annual Report, 1895..............	
Bulletin 37	Composition of Commercial Fertilizers Sold in the State..........................	H. B. McDonnell et al.
“ 38	Potato Experiments..........................	R. H. Miller and E. H. Brinkley.
“ 39	Spray Calendar..................................	R. H. Miller.
“ 40	Composition of Commercial Fertilizers Sold in the State..........................	H. B. McDonnell et al.
“ 41	Test of Methods of Preparing and Feeding Corn Fodder..........................	H. J. Patterson.
“ 42	The Maryland Trees and Nursery Stock Law, and other information of special interest to fruit growers.........	W. G. Johnson.
“ 43	Report upon the Value of the New Corn Product..	H. J. Patterson.
“ 44	The Soils of the Hagerstown Valley......	C. W. Dorsey.
Annual Report 1897	Ninth Annual Report, 1896.............. ...	
Bulletin 45	Composition of Commercial Fertilizers Sold in the State..........................	H. B. McDonnell et al.
“ 46	Corn and Potato Experiments............	R. H. Miller and E. H. Brinkley.
“ 47	Dairy Farming....................................	H. J. Patterson.
“ 48	Some Common Injurious Plant Lice, with Suggestions for Their Destruction	W. G. Johnson.
“ 49	Composition of Commercial Fertilizers Sold in the State..........................	H. B. McDonnell et al.
“ 50	Rust and Leopard Spot; Two Dangerous Diseases of Asparagus................ ...	W. G. Johnson.
“ 51	Horse Feeding: Test of Digestibility of Oats, Corn, Hay and the New Corn Product..	H. J. Patterson.
Annual Report 1898	Tenth Annual Report, 1897.................	
Bulletin 52	Composition of Commercial Fertilizers Sold in the State..........................	H. B. McDonnell et al.
“ 53	Special Investigation of the So-called “New” Horse Disease in Maryland,	S. S. Buckley.
“ 54	Tomatoes..	J. S. Robinson.
“ 55	The Black Peach Aphis; Cut Worms in Young Tobacco; Law Providing for the Suppression and Control of Insect Pests and Plant Diseases in Maryland	W. G. Johnson.
“ 56	Wheat, Winter Oats, Barley and Lime Experiments	R. H. Miller and E. H. Brinkley.
“ 57	Report on the San Jose Scale in Maryland; Remedies for Its Suppression and Control....................................	Do.
“ 58	The Hessian Fly..................................	C. O. Townsend.
Annual Report 1899	Eleventh Annual Report, 1898.............	
Bulletin 59	Sweet Potato Insects..........................	E. D. Sanderson.
“ 60	Some Diseases of the Sweet Potato, and How to Treat Them..............	C. O. Townsend.

Publication.	Title.	Author.
Bulletin 61	The Sugar Beet in Maryland............	H. W. Wiley.
“ 62	Experiments with Wheat, Corn and Potatoes	H. J. Patterson et al.
Annual Report 1900	Twelfth Annual Report, 1899	
Bulletin 63	Experiments with Feeding Pigs............	H. J. Patterson.
“ 64	A Study of the Cause of Mottled Butter,	C. F. Doane.
“ 65	Insecticides, Fungicides and Spraying Apparatus......................	W. G. Johnson, C. O. Townsend and H. P. Gould.
“ 66	Lime: Sources and Relation to Agriculture...	H. J. Patterson.
“ 67	The Culture and Handling of Tobacco,	Do.
Annual Report 1901	Thirteenth Annual Report, 1900	
Bulletin 68	Fertilizer Experiments with Different Sources of Phosphoric Acid...........	H. J. Patterson.
“ 69	The Influence of Feed and Care on the Individuality of Cows....................	C. F. Doane.
“ 70	The Chemical Composition of Maryland Soils	F. P. Veitch.
“ 71	Notes on Spraying Peaches and Plums in 1900..	C. O. Townsend and H. P. Gould.
“ 72	Peach Growing in Maryland...............	H. P. Gould.
“ 73	Suggestions About Combating the San Jose Scale.......................................	H. P. Gould.
“ 74	Notes on the Diseases of Celery............	C. O. Townsend.
“ 75	Hydrocyanic-acid Gas Effect upon Grain and Other Seeds..................	C. O. Townsend.
“ 76	Parturient Paresis—Milk Fever, Calving Fever..	S. S. Buckley.
Annual Report 1902	Fourteenth Annual Report, 1900-1901...	
Bulletin 77	The Digestibility of Raw, Cooked and Pasteurized Milk.........................	C. F. Doane and T. M. Price.
“ 78	The Dehorning of Stock......................	C. F. Doane.
“ 79	The Disinfectant Properties in Washing Powders...	C. F. Doane.
“ 80	Acute Epizootic Leucoencephaltis in Horses	W. G. McCallan and S. S. Buckley.
“ 81	Soils and Fertilizers for Greenhouse Crops..	H. J. Patterson.
“ 82	Thinning Fruits.................................	E. P. Sandstin.
“ 83	Investigations as to the Cause of Pithiness in Celery................................	E. P. Sandstin and Thos. H. White.
“ 84	Feeding Experiments with Cows, and Tables for the Calculation of Rations	H. J. Patterson.
Annual Report 1903	Fifteenth Annual Report, 1901-1902......	
Bulletin 85	Alfalfa for Maryland..........................	W. T. L. Taliaferro.
“ 86	The Influence of Preservatives on the Food Value of Milk......................	C. F. Doane and T. M. Price.
“ 87	The Periodical Cicada and Its Occurrence in Maryland in 1902...........	A. L. Quaintance.
“ 88	Economical Methods for Improving the Keeping Qualities of Milk...........	C. F. Doane.
“ 89	Experiments with Potash as a Fertilizer,	H. J. Patterson.
Annual Report	Sixteenth Annual Report, 1902-1903.....	

CIRCULARS AND CIRCULAR BULLETINS ISSUED BY THE STATE HORTICULTURAL DEPARTMENT.

The State Horticultural Department has issued a number of emergency bulletins, giving special information upon horticultural topics. The following is a list of the circular bulletins issued to date:

No. TITLE.

1. Special Instructions for Treating Trees Infested with San Jose Scale.
2. Special Instructions for Preparing Bordeaux Mixture.
3. Special Instructions for the Destruction of the Apple Plant Louse.
4. Special Instructions for Destroying Cut Worms in Young Tobacco. (Out of print.)
5. Suggestions for Destroying the Peach Tree Borer. (Out of print.)
6. Suggestions for Destroying the Asparagus Beetle.
7. Suggestions for Destroying the Destructive Green Pea Louse. (Out of print.)
8. Suggestions for the Prevention of Plum Rot.
9. Suggestions for the Treatment of Pear Blight.
10. Suggestions for Treating Apple Rust and Scab.
11. Emergency Circular on the Destruction of the Green Pea Louse. (Out of print.)
12. Suggestions for the Use of Bi-Sulphide of Carbon. (Out of print.)
13.
14. Suggestions for the Destruction of the Melon Plant Louse.
15. Emergency Circular on the Treatment of Pear Blight.
16. Special Instructions for Destroying Leaf eating Insects with Paris Green.
17. Special Circular on the Destructive Green Pea Louse.
18. Suggestions for the Treatment of Peach Leaf Curl.
19. An Account of the Destructive Green Pea Louse, and Suggestions for Its Destruction.
20. Second Emergency Circular on Pear Blight.
21. Some Suggestions for the Treatment of Celery Rust.
22. Some Suggestions in Regard to Peach Yellows.
23. List of Maryland Nurserymen.
24. Law Providing for the Suppression and Control of Insect Pests and Plant Diseases in Maryland. (Out of print.)
25. Suggestions for Using Bi-Sulphide of Carbon for the Destruction of Insects in Stored Grain and Seeds.
26. Fall Treatment of Trees Infested with the San Jose Scale.
27. Fall Treatment of Peach Trees Infested with the Peach Tree Borer.
28. Fall Treatment of Pear Blight.
29. A Plain Talk with Those Who Have San Jose Scale to Combat.
30. Black Knot.
31. Suggestions About Combating Tobacco Insects.
32. Cantaloupe Blight.
33. To Agents of Transportation Companies.
34. Treatment of Yellows.
35. Directions for Treatment of Trees and Orchards Infested with San Jose Scale.
36. Winter and Spring Work Against the San Jose Scale.
37. The Periodical Cicada.
38. Spring Advice About Fruit Diseases.
39. Peach Rot.
40. The Way of Spraying.
41. Law Providing for the Suppression and Control of Insect Pests and Plant Diseases in Maryland.
42. Instructions Relating to Nurseries.
43. Peach Yellows.
44. Directions for the Treatment of the San Jose Scale. (Out of print.)

45. Directions for the Treatment of Trees and Plants Infested with the San Jose Scale.
46. The Lime, Sulphur and Salt Wash for the San Jose Scale.
47. The Coddling Moth, and How It May Be Controlled.
48. The More Common Species of Plant-Lice that Affect the Apple, with Suggestions for Their Control.
49. Cutworms, and Methods for Controlling Them.
50. Bordeaux Mixture and Its Use.
51. Apple Diseases and Their Treatment.
52. Insects and Diseases of the Tomato.
53. Digest of State Laws Relating to the Control of Insects and Plant Diseases.

EDUCATIONAL RESULTS OF STATION WORK.

Broadly speaking, probably the most important result of station work has been educational. As a result of the investigations and publications, the agricultural books and journals have been revolutionized. Fifteen years ago the information available to the American farmer was very meager in amount, and, in fact, could not be obtained for love or money. Today every farmer can have a complete and up-to-date library, containing the best information the world has, simply for the asking. One large result of the educational work of the station has been the general breaking down of the popular conception that agriculture is not capable of improvement through systematic and progressive researches in its behalf, conducted on scientific principles. A widespread belief has been awakened that, with the aid of science, agriculture may be lifted out of a dead past, and that it will be able to hold its own amid the growing competitions and complexities of modern trade and civilization. Today the world realizes, as it never did before, that agriculture is a profession demanding as much brains and ability as any business in the world, and that the farmer should be more than "a mere hewer of wood and carrier of water"; more than a mere appendage to a plow; in fact, that the successful coming farmer should be a man who is well acquainted with the arts and sciences and their application to his business, and one, too, whose knowledge of social and political sciences will fit him for the highest duties of a citizen; and the Experiment Stations will have no small part in the consummation of this ideal.

THE FARM.

The work on the general farm is becoming more and more a source of income, and also contributing to a greater extent either directly or indirectly to the experiments in progress, and thus permitting of the enlargement of the Station's sphere of usefulness. The yields obtained from those parts of the farm devoted to the regular rotation are quite satisfactory and are attracting much attention from visitors. This is particularly true of pasture, hay, forage and silage crops.

BUILDINGS.

According to instructions given by the Board at the June meeting one year ago, all the buildings have been thoroughly gone over and repaired and painted. It was also decided to enlarge the tool shed and at the same time provide storage capacity for straw. This was demanded not only for the sake of economy, but also because of the insurance companies objecting to having so much material always stacked near the other buildings.

The repairs cost considerably more than was expected, as the buildings proved, on close examination, to be in worse condition than was anticipated.

STATION STAFF.

During the past year there have been the following changes in the Station Staff:

E. P. Sandsten, Associate Horticulturist, resigned July 1st to accept the position of Associate Horticulturist at the University of Wisconsin. C. F. Austin was appointed to fill this vacancy and entered upon his duties September 15, 1902.

T. M. Price, Assistant Chemist, resigned February 1, 1902, to accept a position in the Biochemical Laboratory of the Bureau of Animal Industry of the U. S. Department of Agriculture. This vacancy has been filled by the appointment of M. N. Straughn, B. S. Md. Agricultural College 1899, M. S. Columbian 1902, who will commence his duties September 1st.

A. L. Quaintance resigned March 1st to accept a position with the Entomological Division of the U. S. Department of Agriculture. This vacancy was provided for, temporarily, by the appointment of Thos. B. Symons as acting Entomologist.

B. H. Gibbs resigned to accept a similar position in the U. S. Government Service in the Philippine Islands. This vacancy has been filled by the appointment of H. H. Howell, graduate of the Washington, D. C., Business High School.

With the close of this fiscal year Prof. James S. Robinson was made Horticulturist Emeritus and relieved of active duties; the active work of the office to devolve upon the Associate Horticulturist.

LABOR.

Each year demonstrates more and more forcibly the necessity for having good, reliable and intelligent labor in order to carry on experiments. The present activity in all the industries and the great demand for labor of all kinds make this class of labor more expensive and harder to procure, especially when quarters are scarce. The conditions here are these: The Station has no quarters for laborers, and located as we are, surrounded by Washington suburban towns, there are few houses available for rent for laboring men, and the few that can be procured are located at a distance, and rents are high. This condition makes it difficult to always procure and hold such labor as is desired.

At the present time most of the Station laborers are paying $5.00 to $10.00 per month rent and living one to three miles from the Station. The rents take too large a proportion of their wages, and the best returns cannot be expected when a man must walk as much as three miles to his work and then the same distance after his day's labors are finished. I therefore would recommend that steps be taken to provide, at once, at least two small houses and supplement this from year to year until sufficient quarters are available for at least all monthly laborers.

APPRENTICES—SCHOLARSHIPS AND FELLOWSHIPS.

Three years ago the Station offered, for the first time, apprenticeships in dairying and horticulture. These have not been a success, or at least have not worked out in the manner desired. This has been due principally to the fact that there is not a real demand for this class of aid, and again the people of the State fail to properly appreciate the opportunity offered by such apprenticeships. From these facts we have failed to procure either the number or character of apprentices which would enable the scheme to work mutually satisfactory.

Scholarships.—The time of some of the Station officers is so consumed with teaching and routine duties of various kinds as to permit them to do very little in the way of following details of some side lines of investigations which would be contributory to the experiments in hand and often open up new lines of work; yet they have time to plan and give general directions to such investigations. Very often these preliminary studies could be performed by students who are specializing during the junior and senior years. Such a plan should stimulate the professor in his work, and be particularly inspiring to students to pursue studies and write a thesis which will be of use to the world and could be published as a Station Bulletin, and it would have more value than simply to enable graduation.

In order to carry out this idea, I would suggest the propriety of establishing Station Scholarships, to be awarded to aid students of the senior year who are pursuing some investigations relating to agriculture or horticulture. Those competing for the scholarship shall commence their investigations not later than the second term of the junior year, and awards of scholarships paid on the satisfactory completion of the senior year's work. The amount of such scholarship shall be determined from time to time, and depend upon the character of the work in hand, but shall not exceed $100.

Fellowships.—To enable the extension of the ideas expressed under scholarships, I believe it would be well to establish fellowships, to be awarded to those whose investigations are not completed and upon which further work was deemed advisable. These fellowships to be awarded for such time and amount as may be deemed necessary, but shall not exceed $300 per year. Provision has been made for these scholarships and fellowships.

FINANCIAL CONDITION.

As will appear from the report of the Treasurer, the year will be closed with all bills paid and a small balance. Nevertheless, the Station could use considerably more money upon investigations in hand at the present time, as all departments are more or less hampered for proper equipment and other facilities. Then, too, there are many investigations which should receive attention that cannot be begun because the present income will not warrant further expansion.

The Treasurer's report for the fiscal year ending June 30, 1903, is as follows:

MARYLAND AGRICULTURAL EXPERIMENT STATION IN ACCOUNT WITH THE UNITED STATES APPROPRIATION.

1903.	DR.	
June 30—To	Receipts from the Treasurer of the United States, as per appropriation for the fiscal year ended June 30, 1903, as per Act of Congress, March 2, 1887	$15,000.00

1903.	CR.	
June 30—By	Salaries	$ 7,799.00
"	Labor	2,988.59
"	Publications	264.84
"	Postage and Stationery	183.28
"	Freight and Express	203.74
"	Heat, Light and Water	332.21
"	Chemical Supplies	158.70
"	Seeds, Plants and Sundry Supplies	765.43
"	Fertilizers	175.26
"	Feeding Stuffs	300.50
"	Library	285.38
"	Tools, Implements and Machinery	304.04
"	Furniture and Fixtures	113.60
"	Scientific Apparatus	158.41
"	Live Stock	360.00
"	Traveling Expenses	228.08
"	Contingent Expenses	15.00
"	Buildings and Repairs	363.94
		$15,000.00

The above is a true copy from the books of this office.

JOS. R. OWENS,
Treasurer Maryland Agricultural Experiment Station.

Maryland Agricultural Experiment Station in Account with the Station Farm.

1902.	DR.	
July 1—To	Cash Balance from sale of Farm Stock and Produce	$ 20.40
1903. June 30—To	Sales of Stock and Produce during the year ended June 30, 1903	4,257.58
		$4,277.98
1903.	CR.	
June 30—By	Labor	$1,663.75
"	Seeds, Plants and Sundry Supplies	445.83
"	Feeding Stuffs	903.00
"	Tools, Implements and Machinery	283.50
"	Live Stock	276.00
"	Insurance, Auditing and Trustees' Travel	390.33
"	Travel Expenses	186.92
"	Cash Balance	128.65
		$4,277.98

The above is a true copy from the books of this office.

JOS. R. OWENS,

Treasurer Maryland Agricultural Experiment Station.

Maryland Agricultural Experiment Station in Account with the State of Maryland.

1903.	DR.	
June 30—To	Receipts from the Treasurer of the State of Maryland, as per the fiscal year ending September 30, 1903, as per Chapter , Section , Laws of 1902	$5,000.00
1903.	CR.	
June 30—By	Repairs to Buildings	$3,262.18
"	Publications	1,151.53
"	Feeding Experiments	445.65
"	Live Stock	32.00
"	Fair Exhibit	95.00
"	Balance Cash	13.64
		$5,000.00

The above is a true copy from the books of this office.

JOS. R. OWENS,

Treasurer Maryland Agricultural Experiment Station.

Report of the Treasurer of the Maryland Agricultural Experiment Station,

From 1888 to 1903, Inclusive.

	1888.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.		1902.		1903.		
														U. S. Funds.	Farm Sales.	U. S. Funds.	Farm Sales.	U. S. Funds.	Farm Sales.	Stat Fund
RECEIPTS.																				
U. S. Appropriation	15000 00	15000 00	14998 65	5000 00	15000 00	15000 00	15000 00	15000 00	15000 00	14993 47	15000 00	15000 00	15000 00	15000 00	......	15000 00	......	15000 00	......	......
Farm Sales	......	......	......	......	......	488 12	590 03	1048 15	733 86	1194 04	1427 56	1856 07	2830 94	......	4410 08	......	4808 89	......	4257 58	......
Balance	......	......	1 35	......	......	......	3 95	394 07	616 34	87 72	430 56	522 89	5 96	......	98 72	......	723 31	......	20 40	......
Total Receipts	15000 00	15000 00	15000 00	15000 00	15000 00	15488 12	15593 98	16442 22	16350 20	16275 23	16858 12	17878 96	17886 63	15000 00	4538 80	15000 00	5532 23	15000 00	4277 98	5000
Total Expenditures	14975 28	14993 65	15000 00	15000 00	15000 00	15484 17	15199 91	15825 88	16262 48	15844 67	16335 23	17373 27	17737 91	15000 00	3815 46	15000 00	5511 83	15000 00	4149 33	1986
Balance	24 72	1 35	......	......	......	3 95	394 07	616 88	87 72	430 56	522 23	5 69	98 72	......	723 34	......	20 40	......	128 65	13
EXPENDITURES.																				
Salaries	1369 22	6285 00	7794 00	7614 75	6282 50	5972 63	7819 99	8055 26	7619 10	8267 26	8188 84	6636 58	7375 92	7533 44	......	8025 61	......	7799 00	......	......
Labor	604 29	1970 28	1630 00	2551 23	2417 75	2267 25	2010 38	2125 19	2226 46	2559 39	3114 90	3114 86	3648 06	2765 79	1379 41	2690 52	1782 93	2988 59	1663 75	......
Freight & Express	175 71	404 64	183 95	329 09	375 17	527 40	630 30	459 96	139 15	136 96	154 29	171 79	235 6	284 18	......	100 00	382 26	203 74	......	......
Postage & Stationery	116 60	353 54	......	134 93	82 52	52 35	34 81	140 21	76 43	182 72	120 83	152 53	134 17	134 81	......	105 30	......	183 28	......	......
Publications	39 20	855 52	884 26	951 65	1306 29	1390 58	951 39	1661 36	932 28	992 15	610 02	699 79	851 18	1161 37	......	671 85	......	264 84	......	1151
Seeds, Plants & Sundry Sup'l's.	661 14	1499 22	997 65	1692 08	1341 53	2428 37	1720 10	......	302 30	314 60	410 02	600 60	761 04	468 46	244 81	468 03	452 00	765 43	445 83	......
Library	1585 83	216 49	250 62	266 80	363 41	159 50	169 00	70 11	105 42	20 59	119 91	595 59	199 94	130 22	......	358 94	......	285 58	......	......
Tools, Implements & Machin'ry	503 33	310 57	397 70	369 75	206 08	845 44	411 06	331 39	836 44	295 27	596 96	832 05	1459 62	......	381 78	505 80	500 00	304 04	283 50	......
Scientific Apparatus	564 35	122 73	300 00	56 00	......	......	......	41 10	38 06	43 42	16 12	573 27	138 70	68 70	......	97 40	......	158 41	......	......
Chemical Supplies	1311 60	78 40	......	......	......	......	......	59 17	85 10	77 15	85 52	70 11	152 80	91 20	......	203 89	......	158 70	......	......
Furniture & Fixtures	3263 93	1118 56	......	......	......	......	......	92 67	3 15	59 72	179 80	214 69	11 00	226 67	......	191 04	......	113 60	......	......
Buildings & Repairs	4134 85	840 05	1076 52	916 34	834 50	573 92	590 21	825 06	2017 57	327 02	1058 99	1847 48	293 18	418 32	......	740 11	743 11	363 94	......	3262
Live Stock	490 00	15 00	......	......	......	......	......	581 61	487 75	719 00	340 50	130 00	202 50	245 00	587 95	64 93	......	360 00	276 00	32
Travelling Expenses	102 83	528 55	934 18	663 69	840 50	455 13	279 00	241 52	306 34	81 80	121 94	137 95	207 41	247 46	134 56	64 42	......	228 08	186 92	......
Feeding Stuffs	......	......	215 12	190 98	131 00	396 50	430 00	244 03	397 54	957 30	729 52	1039 12	1073 33	462 37	924 70	241 68	1400 05	300 5	903 00	445
Heat, Light & Water	......	......	......	......	......	......	345 30	......	309 71	495 8	242 09	300 17	355 58	372 89	......	341 70	......	332 2	......	......
Fertilizers	......	......	......	......	......	......	225 36	......	57 90	132 52	168 99	101 30	439 83	79 09	172 25	100 83	128 00	175 26	......	......
Contingent Expenses	49 40	40 00	312 17	79 64	......	......	......	15 25	241 70	191 00	77 00	135 00	158 00	10 00	......	15 00	123 47	15 00	390 23	95
Total Expenditures	14975 28	14993 65	15000 00	15000 00	15000 00	15484 17	15199 91	15825 88	16262 48	15814 67	16335 23	17373 27	17737 91	15000 00	3815 46	15000 00	5511 80	15000 00	4149 33	1936

WEATHER REPORT.

The weather for the growing seasons of 1902 was not very favorable, throughout, for the best crop production. April and May were dry and caused a short hay crop. The season for corn was good. The fall was extremely wet and made it impossible to prepare some land for fall-seeded grain, and none of it was in the best shape for seeding. The following table, A, gives the summary of the meteorological records made at College Park. In Table B are given the normal temperatures and rainfalls at College Park, Cumberland, Baltimore and Washington, D. C., for comparison.

TABLE A

METEOROLOGICAL SUMMARY FOR COLLEGE PARK, 1902.

Temperature in Degrees (Fahrenheit).

MONTH.	PRECIPITATION.	TEMPERATURES—MEAN.				EXTREME MAXIMUM.	EXTREME MINIMUM.
		Daily Means.	Maximum.	Minimum	Daily Range.	Record and Date.	Record and Date.
January	3.72	29.7	40.0	19.4	20.6	49, 15th	8, 6th
February	4.45	27.8	38.0	17.6	20.4	59, 28th	—3, 5th
March	3.54	46.4	59.0	33.8	25.2	78, 29th	18, 19th
April	2.25	52.8	65.1	39.6	25.5	89, 22d	27, 4th
May	2.70	63.9	77.3	50.5	26.8	91, 23d	35, 16th
June	4.10	70.8	84.7	56.9	27.8	97, 13th	43, 9th
July	6.21	77.0	89.6	64.5	25.1	100, 18th	54, 17th
August	3.48	70.9	84.3	57.5	26.8	91, 1st	45, 17th
September	7.39	65.2	77.5	52.9	24.6	89, 1st	38, 15th
October	5.78	56.3	68.4	44.2	24.2	80, 25th	26, 30th
November	3.95	49.8	61.7	37.8	23.9	76, 13th	23, 29th
December	5.21	32.8	42.7	23.0	19.7	60, 21st	7, 26th
Yearly	52.78	53.6	65.7	41.5	24.2	100. July 18	—3. Feb. 5

TABLE B.

NORMAL TEMPERATURE AND RAINFALL.

PLACE OF RECORD.	TEMPERATURE.		RAIN AND SNOW-FALL.	
	Normal.	Mean for 1902.	Normal, in Inches.	In 1902, Inches.
College Park, Md	54.6	53.6	42.70	52.78
Washington, D. C	54.7	54.9	44.77	46.60
Baltimore, Md	55.2	55.2	43.95	50.13
Cumberland, Md	55.6	......	33.73	....

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ALFALFA FOR MARYLAND.

BY W. T. L. TALIAFERRO.

INTRODUCTION.

The short hay crop in Maryland this season of 1902 has greatly emphasized the need for the addition to our forage plants of some crop more drought-resistant than timothy and clover. The most available seems to be Alfalfa, that wonderful plant which in our dry Western States has proven such a boon to the farmer and stockman, clothing the semi-arid plains with richest verdure, and yielding a harvest more valuable than all the gold and silver ever taken from their mines.

That alfalfa may be successfully grown in some parts of Maryland is a well-established fact. That it may be grown more generally is confidently believed. The object of this bulletin is to stimulate an already awakening interest in alfalfa, and to assist and encourage the farmers of the State in its cultivation. In the preparation of the matter presented in this bulletin, information has been sought wherever available from the publications of the United States Department of Agriculture and of various States, and especially from the close study and comparison, on the spot, of the conditions under which alfalfa is growing and has been grown in this State, both at the Experiment Station and by private individuals in a number of counties. In order to encourage farmers to try alfalfa experimentally, and to get the necessary data as to its adaptability to Maryland conditions, this Station, in co-operation with the U. S. Department of Agriculture, distributed seed to farmers in different parts of each county in the State. In many cases gratifying results have already been obtained, and much valuable information has been gained, which will be embodied in this bulletin. As further developments occur and more definite information is acquired, they will be given in a later bulletin.

HISTORY.

Alfalfa is a native of Western Asia, whence it was early taken to Southern Europe. The Spaniards carried it with them to South America. In the arid and semi-arid regions along the western slopes of the Andes it found a congenial home and is the principal forage crop. From Chili it was taken to California and thence spread throughout the dryer portions of the West. Everywhere it has added immensely to the stock-carrying capacity of farm and ranch. Its great value as a feeding crop becoming better recognized, an effort has been made to extend the use of it, and there is probably no State now in which it is not growing at least experimentally.

Alfalfa is also called Lucern, that being the name by which it is known in France and Italy. Various attempts have been made in our Atlantic States to grow it from French and Italian seed, but without known success. The change of climate is thought to be too abrupt. It is the alfalfa which has been subjected for generations to the hot, dry climate of Spain and Chili that seems best adapted to our conditions. Recently the U. S. Department of Agriculture has imported from Turkestan a variety which is remarkable for its ability to resist great extremes of heat and cold. It is thought that this will be particularly valuable for the States of the Northwest.

CHARACTER OF THE PLANT.

Alfalfa belongs to the botanical order Leguminosæ, or legume family, to which belong also the clovers, peas, beans and many other plants having pea-like blossoms and podded fruit. Like other members of the family, alfalfa is tap-rooted—that is, it has a long central root which it sends down into the soil sometimes to an incredible depth where the subsoil is light and open. This strong growing tap-root is one of the important characters of alfalfa, for by means of it the plant is able to draw upon supplies of water and plant food from depths far below the reach of ordinary field crops. Where the subsoil is hard and stiff, the tap-root is liable to be broken up into a number of branches which do not penetrate to the depth of the single root.

Above ground, alfalfa sends first a single stalk. When this becomes old or is cut off, new stalks start near the surface of the ground, making a crown which enlarges as the plant gets older and more crops are cut off. Forty or fifty stalks from a single crown and even a hundred or more are not unusual with old plants.

The flowers of alfalfa are borne towards the top of the stalk and are of a pink color. A field in full bloom is a beautiful sight. The blossoms exhale a delightful fragrance and furnish to the busy bees large quantities of delicious honey. As much as two hundred pounds of honey in a season have been taken from single hives in the alfalfa regions.

Where alfalfa is grown for seed it is necessary that bees be kept in order to pollenate the flowers, the plant richly repaying the industrious insects for their indispensable, if unknowing, service.

As a rule the first crop of alfalfa is not very productive of seed, the second crop being usually devoted to that purpose. The seed are borne in spirally coiled pods.

Alfalfa is a perennial—that is, it lives for an indefinite period. It is said that fields have produced profitable crops for fifty years, but that is under exceptional conditions of soil and climate. Five or six years will probably be found the limit of profitable production in Maryland, except where conditions are peculiarly favorable. By the end of that time the plants become thinned out and weeds get in. It will be found best before renewing the field to put it for at least two years into some clean cultivated crop. To get rid of alfalfa it should be plowed in midsummer and kept cultivated.

The growth of wheat, corn, potatoes, etc., is limited strictly by the amount of nitrogen in the soil and available for use. If it is not in the soil, it must be supplied artificially or there can be no crop. This is not the case with alfalfa. Being a legume, it has, under normal conditions, the power of converting atmospheric nitrogen into active plant food. Five tons of alfalfa hay will contain about 220 pounds of nitrogen, the larger part of which was gotten from the atmosphere. This much hay may be taken from an acre of land for several years and at the end of that time there remain in the soil more nitrogen than was in the soil when the alfalfa was planted. This power of converting atmospheric air into plant food is dependent upon certain minute forms of life called bacteria, which cause and inhabit little nodules or tubercles on the roots of the plants.

Until the tubercles develop, which occasionally does not happen, legumes are as dependent as other plants on soil nitrogen. An abundant supply of available nitrogen should therefore always be furnished young alfalfa to tide it over the critical period of its youth, when it has not the power to help itself.

TIME OF SEEDING.

Alfalfa may be sown either in the spring or in the fall. If in the fall, it should be early enough for the young plants to get well established before cold weather. In Maryland the best time would seem to be the latter part of August or first of September, preferably in August if there are seasonable rains. If the soil has been properly prepared, there will be few weed seeds in it at this time, and such weeds as start will be cut down by frost before they can do much harm. If the planting be late, or if, owing to a dry season or faulty preparation, the seed do not come up and grow promptly, there is great danger that they will not survive the winter. The young alfalfa plants are very tender and sensitive to drought and cold. They are also very liable to be heaved out by frost, since they have only a single straight tap-root with no laterals.

For spring seeding the best time in Maryland would appear to be the last of March or first of April if the weather be favorable and the ground well drained. The objections to spring seeding are the liability to be caught by a freeze when the plants are but two or three days old, which is apt to be disastrous; the liability to have the young plants drowned out by excessive rains, and the danger of their being smothered by weeds. Young alfalfa plants are extremely sensitive to wet. If they stand with wet feet but a few hours, they stop growing and turn yellow, and if it be continued they perish.

The susceptibility of the plants to excessive moisture was strikingly illustrated at this Station this season.

A piece of sandy loam soil, underlaid at the depth of about three feet with a rather dense material, was planted on the 29th day of April, the seeding having been delayed while the lower part of the tract was underdrained. May and June were very dry months, yet the alfalfa grew beautifully and perfectly even, except at the extreme upper end, where a crop of crimson clover turned down too late had kept the earth from becoming firm and interfered with the upward passage of soil water. The first of

July the alfalfa over the greater part of the tract was thick, green and vigorous, and from eight to twelve inches high. On the "clover land" it was from four to six inches high, thin and sickly. Then came the rain and the conditions changed. Though there was probably not twenty-four hours during some part of which the entire field was not dry enough to have been nicely cultivated, yet the alfalfa in the lower part seemed to get smaller, while on the upper part, which is underlaid with gravel, it took on a dark green color and began to grow vigorously, so that by the middle of the month it was from twelve to fourteen inches high and beginning to bloom.

Mr. Asa Stabler, of Montgomery county, had a somewhat similar experience in 1901. He put his alfalfa on a slope which gave perfect surface drainage, but yet when seen in the spring of 1902 the lower part of the slope was absolutely bare of alfalfa, while the upper part was a fair stand. Mr. Stabler attributed the difference entirely to the greater amount of water on the lower slope, which seemed to be too wet for alfalfa, though well adapted to wheat and grass.

PREPARATION OF THE SOIL.

Alfalfa is a plant of vigorous growth when once it has become established, but when it first starts is very weak and delicate. To insure a crop, ample preparation should be made, and the conditions surrounding the young plants should be made as nearly perfect as is possible to get them.

The conditions required are a deep soil, a fertile soil, a clean soil, a well drained soil, and if it can be had, a loose, open subsoil. Experience has shown that unless proper conditions can be furnished it is useless to attempt to grow the plant in Maryland. It has also been demonstrated that where these conditions can be had, and they can in very many parts of the State, there is nothing in our climate to prevent its successful growth.

As a rule it will be found advisable to get ready for the crop at least two years ahead of the time when it is expected to be planted.

Select, if it can be had, a piece of ground of light character with a porous subsoil, through which all surplus water will quickly descend below the roots of the plants. If such a soil cannot be had, one with a dry subsoil will answer, though not quite so well, provided there be at no time standing water within four or five feet of the surface. Where it is not naturally dry under-drainage must be resorted to. During the preliminary period the ground must be kept in clean cultivated crops—actually, not nominally, clean cultivated—and the manure intended for the alfalfa had best be applied at this time. When only a small piece of ground is being prepared it might be used as a truck patch. That would enable the farmer to apply large amounts of manure and fertilizer and make an immediate profit from them, while storing up the residue and cleansing the soil for the alfalfa. Whereas, if the manure be applied directly to the alfalfa, it will tend to make it weedy. Where larger pieces of land are required, they must still be put into such crops as will demand and receive clean cultivation and heavy manuring, using crimson clover or other catch crops between seasons.

Where convenient to do so an alternation of smothering crops, as crimson clover and cowpeas, with frequent stirring of the surface of the soil, should make an ideal preparation. As, for instance, follow corn or early potatoes with crimson clover; plow the cover down deep, nine or ten inches, the first of May. Roll and harrow with cutaway or spring-tooth harrow at intervals till the first of June, then plant to cowpeas. Plow down the peas the middle of July, put on 30 bushels of lime to the acre, roll and harrow as before. This will compact the lower soil and stir the upper. It will also kill off weeds and retain moisture to germinate the seed sown the last of August. Alfalfa requires a fine, firm, mellow seed-bed, free from lumps and clods, and having close capillary connection with the subsoil. This can only be where soil has been plowed long enough for it to settle and the underturned vegetable matter to rot. For that reason never sow alfalfa on newly-plowed land. If the peas cannot be plowed down in time for them to rot, it would be better to cut off the vines for hay and work up the surface soil only with a disc or cutaway harrow.

As even slight depressions, which catch the rain water and hold it for a short time, have a bad effect on alfalfa, it is well to go over the land with a rubber or smoother of some kind to make the surface even.

When the soil is firm and compact below, fine and mellow above, sow the seed, twenty pounds to the acre. Sow ten pounds first and the other ten pounds crossing the field at right angles to the former direction. This precaution may seem unnecessary, but will more than repay the cost in the greater regularity of stand. After sowing harrow in the seed with a light slant-tooth or smoothing harrow and roll. Put in in this way in a soil well supplied with available plant food, the seed will germinate promptly and the young plants pass quickly beyond danger from weeds and the vicissitudes of the season.

For spring seeding the land should be plowed the fall before, ten inches deep. In March it should be given a dressing of thirty bushels of lime to the acre and be thoroughly worked up with harrow, roller and rubber. Plant as indicated above.

SUBSOILING.

In stiff clay subsoils, especially where long-continued shallow plowing has caused a "hard-pan" to form, it is not desirable that much raw subsoil be brought to the surface by deep plowing, and yet it is necessary that the soil be deeply stirred. In such cases it is well to use the subsoil plow, running it in the furrow made by the turning plow. It should be borne in mind that the best results from subsoiling usually follow that done in the fall because of the length of time required to re-establish close capillary connection.

NURSE CROPS.

As a rule nurse crops should not be used with alfalfa. Though fine stands have been secured with them, it was rather in spite of than in consequence of them. The young alfalfa plants are delicate and need all the sunlight, food and water they can get. How, then, can they do as well if the lion's share of these are taken from them by stronger and hardier plants? No instance has been reported in this State where a nurse crop was beneficial, but several where it was injurious.

Wing, the Ohio expert, recommends the use of beardless barley with alfalfa when sown in the spring, the barley to be harvested when ripe. Some fine crops have been grown in Maryland from sowing the seed like red clover on wheat land in March, but such a practice is not to be commended. A majority of growers are opposed to it and report best results from both fall and spring seeding without a nurse crop. Among those who report the nurse crop as a drawback are Dr. Augustus Stabler and Mr. Robert H. Miller, of Montgomery county, and Mr. F. A. Posey, of Charles.

The history of a five-acre field of alfalfa at the National Soldiers' Home, in the District of Columbia, a few miles from the Maryland Agricultural College, will be interesting in this connection, as reported by Mr. T. McGrath, the farm manager. The location is on top of a gravel hill. It was for two years used for trucking crops and well fertilized with manure and fertilizer. In the fall of 1899 the land was plowed deep. The next spring it was worked up, and the seed were sown in April without a nurse crop. About June 20th, 1900, a cutting of two tons of hay to the acre was made, and thirty days afterwards another cutting of one and a-half tons. It was then pastured. In 1901 three cuttings were made and pasturage. Mr. McGrath, by the way, thinks the alfalfa was hurt by pasturing. In 1901 an application of four hundred pounds of pure raw bone to the acre was made over a part of it. At the first cutting in 1902 a yield of three tons of hay per acre was made, though the season was so dry that not half a hay crop was made from red clover and orchard grass.

It may appear to some that too much importance has been attached, in this bulletin, to the preparation of the soil, but the experience of Mr. McGrath on the one hand and the contrary experience of many others who were not so particular is sufficient justification for all that has been said.

TREATMENT DURING EARLY STAGES OF GROWTH.

The first summer is generally a critical time in the life of the young alfalfa plant. Weak as it usually is, it is called upon to withstand extremes of wet and drought and, worse yet, the smothering of greedy weeds.

The mower is the best remedy for these ills. Cut close and often. If the cutting be heavy, haul it off; if light, and the weather be dry, it may be left for a mulch. This frequent clipping is very important. It diminishes the evaporating leaf surface, it promotes branching, and it keeps down the weeds and lets in the sun and air. Alfalfa should never be allowed to stand beyond early bloom. To do so weakens the vitality of the plant and makes it less able to recover. It should not, however, be mowed so late in the fall as not to leave a cover to protect it during winter.

It is evident, from an examination of reports sent in by our correspondents, that the greatest enemy to alfalfa in Maryland is weeds. To this cause more than all others can be traced the untimely ending of many a field of it which in the first few weeks of existence gave such fair promise of success. Therefore it is all-important to kill out all weeds possible beforehand and then with the mower to keep down all those which do appear. If the alfalfa be thick and the weeds few, they may be controlled by mowing. If the alfalfa be thin and the weeds many, it would be better to plow it up and put the land in a cleansing crop for another trial. After the first year, if the soil be adapted to the crop, alfalfa will smother out all weeds that invade it.

A method of seeding which is practiced by some is to sow in drills about fourteen inches apart and cultivate between the rows. In this way the soil can be kept in better condition and the weeds kept down until the alfalfa has become strong enough to protect itself. While this method involves more labor than broadcast sowing, it is more certain to make a crop on weedy land and in adverse seasons. In 1893 a good stand was secured at this Station in this way, while a field sown broadcast on similar land was a failure.

This method of drilling the seed and cultivating may be often used advantageously on small lots while larger areas are being prepared for broadcast sowing by means of clean cultivation or cleansing crops.

CULTIVATING.

Many successful growers in the West have adopted the plan of cultivating it by going over their fields in the early spring with a disc or cutaway harrow weighted and run two ways. For the time the crop seems ruined, but the stirring of the soil and the slicing of the crowns are evidently beneficial, for the yield is often doubled by the treatment. This is not generally done till after the third year.

FERTILIZERS FOR ALFALFA.

As stated above, alfalfa is a legume, and after it becomes inoculated with the nitrifying bacteria, gathers its own nitrogen from the atmosphere. Until that time, however, it must be fed with readily available nitrogen. This may be given in an application of fifty or a hundred pounds of nitrate of soda per acre, applied just before seeding. A good mixture would be:

Nitrate of soda	50 lbs.
Acid phosphate	350 "
Muriate of potash	100 "
Total	500 lbs.

Use this quantity per acre.

Alfalfa draws heavily upon the mineral elements of the soil, and where these are lacking large crops cannot be expected. It is true that by means of its long tap-root it obtains plant food from depths beyond the reach of other crops, but in humid regions the further we go below the surface the smaller becomes the proportion of available plant food.

Four tons of alfalfa hay contain:

Phosphoric acid	40 lbs.
Potash	135 "
Lime	272 "
Nitrogen	175 "
Total	622 lbs.

The minerals are all taken from the soil, and if that is not to become exhausted they must be returned to it by liberal annual applications of muriate of potash, with acid phosphate or rawbone applied before the field is disced in the early spring. Lime should be spread when the field is plowed. As in all cases when fertilizers are used, it is well for the farmer to experiment for himself. To illustrate this point may be cited the experience of Manager McGrath, of the National Soldiers' Home, and of Mr. J. A. Chapman, of Charles county. The former applied fine-ground rawbone at the rate of 400 pounds per acre to the poorer portions of his field and with the result that those portions made the best crops. Mr. Chapman, on the other hand, applied in parallel strips, acid phosphate, rawbone, nitrate of soda and muriate of potash. The resulting crops were not weighed, but when the field was examined two days before cutting there was no apparent difference between these plats and the unfertilized portions on each side of them. Mr. Chapman did, however, get most marked beneficial results from stable manure applied as a top dressing in winter. When alfalfa has become established there is no danger of stable manure making it weedy, because it grows so strongly it smothers the weeds. The alfalfa which had been top-dressed with manure was as clean as the rest of the field. Not even Bermuda grass nor waxweed, two of the most aggressive plants of that section, were to be found in it, though they skirted the field and occupied some spaces which had been missed by the wheelbarrow seeder.

AS A FERTILIZER OR SOIL IMPROVER.

Alfalfa, being so long-lived and more or less difficult to start, can never be used as a fertilizing crop in any ordinary rotation. It does, however, improve the land on which it grows both by the addition of organic nitrogen and by opening up and aerating the deeper layers of the soil by means of its fleshy, deeply penetrating roots. When these roots die and decay, they leave channels for the passage of air and water to a greater depth than any other cultivated herbaceous plant.

At the Wyoming Experiment Station a piece of virgin land was put in alfalfa for five years, and an adjoining piece of equal size put for the same length of time in a short rotation of wheat and potatoes. At the end of the period each field was put in plats of wheat, oats and potatoes. The value of the crops was, for wheat from $8.00 to $12.00, for the potatoes $16.00, and for the oats $16.00 more per acre for the half which had been in alfalfa than from the half which had been in the rotation of wheat and potatoes.

After all, however, the great value of alfalfa as a fertilizer is in the immense quantity of nitrogen which it takes from the air and gives to the farmer in the shape of protein for his live stock. If the farmer feeds the protein and puts the carefully saved manure on his land he utilizes the full fertilizing value, for in that case there is but little waste of minerals and a constant addition of available nitrogen. But if, on the other hand, he sells the hay as such, the loss of mineral elements will be very great and must be accounted for.

ALFALFA AS A PASTURE.

Alfalfa should be fed as a hay or as a soiling crop. It is not, as a rule, wise to pasture it. When it is pastured the hoofs of the animals break off the buds and injure the crowns. This is especially the case when the ground and plants are frozen or when it is very dry. Alfalfa differs from most other plants in that when a stalk is cut off the remaining portion does not, as a rule, send up another shoot from below the injury, but dies back to the crown, from which a new bud starts. It is these young buds that are broken off by the trampling of stock.

Except for the damage to itself from the trampling, it makes excellent pasturage for horses and hogs. At the Kansas Experiment Station it was calculated that an acre of good alfalfa pasture would produce from 500 to 1000 pounds of pork. For ruminant animals it makes an unsafe pasture. Sheep and cows turned on it are liable to eat too greedily and be attacked with bloat. They may, however, be pastured on it with little danger if gradually accustomed to it. A method in vogue in the West is to turn the cattle on to the alfalfa just after they have been full fed on some other feed. If allowed to remain then in the field constantly, there will be no danger. Old fields on which the alfalfa has largely been replaced with blue grass make a safe, productive and nutritious pasture.

ALFALFA A SOILING CROP.

The most satisfactory way in which to feed alfalfa green is as a soiling crop, as which it has no superior in quantity and quality and time of service. For soiling, cutting may begin by the first week of May on fairly warm, fertile soils, and another cutting may be had thirty days later if the weather be not too dry. Under good conditions three or four cuttings a year may be looked for, making a total of fifteen to twenty tons of the finest green forage that can be grown—the most palatable to stock and the most nutritious. This green forage is equally good for horses at hard work as for dairy cows. Mr. S. S. Merritt, of Baltimore county, has for years been feeding his horses green alfalfa throughout the summer to the exclusion of other long forage, and reports that they do splendidly on it. Mr. Merritt operates a successful truck farm near Grange P. O. and raises alfalfa just to furnish summer forage.

It is not well to depend entirely upon alfalfa for a succession of green forage during the summer, for in order to do that some of the crop must be allowed to remain too long uncut. This has an injurious effect on the following cuttings. For cows, especially, it is well to have crops of green corn to feed during the summer between the crops of alfalfa. The variety will be agreeable to them. On no account must an alfalfa crop, either for soiling or for hay, be allowed to go to seed or to stand after the leaves begin to yellow. The ripening of the seed so reduces the vitality of the plant that it is not apt to recover that season. The yellowing of the leaves is due to a disease which is liable to kill the plants if not checked by immediate mowing.

ALFALFA HAY.

For hay alfalfa must be cut when in early bloom. It is then in its best feeding condition and will recover readily for the next cutting. If the harvest be delayed, the quality of the hay will not be so good and recovery will be slow and incomplete.

Wing makes a strong point of early mowing. When the crop is ready, he says, especially if the leaves have begun to yellow, it must be cut promptly, even if the weather be so stormy that it is impossible to save the hay. It is better to lose that one mowing than to lose two or three later mowings or perhaps the entire field by waiting.

Alfalfa is liable to loss if not carefully handled. If put away before it is sufficiently dry, it is liable to heat. If it gets too dry the leaves fall off and the feeding value is lessened. The best plan seems to be to mow in the morning after the dew is off. When the hay is wilted but not dry enough to drop the leaves, rake it up and let it cure in the windrows. If the weather seems stormy, it may be put into cocks for the night and opened out the next morning. It is important that the hay be handled as little as possible to avoid loss of the leaves, which come off readily when dry. Alfalfa hay is easily injured by wet, losing as much as half its feeding value when exposed to one or two rains. Like clover hay it does not turn water readily and should be put under cover, or if required to be stacked the stack should be topped with straw. It is recommended by some growers to pack alfalfa hay in the mows in alternate layers with wheat straw. It is claimed that this prevents heating and that the straw becomes so strongly flavored that the stock eat at it as greedily as they do the true hay.

FEEDING VALUE OF ALFALFA.

Alfalfa belongs to that class of feeds which are especially rich in the proteids, or muscle and cheese-making elements. It is not a perfect food, for it lacks the proper amount of the carbonaceous or heat and fat-making materials. These latter are, however, abundantly supplied by corn products, and it is in connection with that crop that alfalfa finds its greatest usefulness. Director Jordan, of the New York Experiment Station, says in his work, "The Feeding of Animals," that "probably no species of forage plants are known that are more economical sources of high-class cattle food than alfalfa and maize." Fortunate is the farmer who can grow both of these crops. For him the problem of balanced rations is of easy solution at a minimum of cost. No portion of the country is better adapted than Maryland to the production of corn, and if the growing of alfalfa can be made general there is indeed a bright future before the live-stock industry and all that it implies in this State.

The proper use of alfalfa in the feeding ration will be best understood by a study of the following figures, showing the number of pounds of dry matter and of digestible food constituents in one hundred pounds of alfalfa and several common feeds. They are taken from the Year Book of the U. S. Dept. of Agriculture for the year 1895:

	Dry Matter.	Protein.	Carbohydrates.	Fat.
Green materials:				
Alfalfa	28.2	3.89	11.20	.41
Cowpeas	16.4	1.68	8.08	.25
Crimson Clover	19.3	2.16	9.31	.44
Red Clover	29.2	3.07	14.82	.69
Corn Forage	20.7	1.10	12.08	.37
Corn Silage	20.9	.55	11.79	.65
Rye Forage	23.4	2.05	14.11	.44
Kentucky Blue Grass	34.9	3.01	19.83	.83
Hay from:				
Alfalfa	91.6	10.58	37.33	1.38
Cowpeas	89.3	10.79	38.40	1.51
Red Clover	84.7	6.58	35.35	1.66
Timothy	86.8	2.89	43.72	1.43
Corn Stover	59.5	1.98	33.16	.57
Concentrates:				
Wheat Bran	88.5	12.01	41.23	2.87
Corn and Cob Meal	84.9	6.46	56.28	2.87
Corn Meal	85.0	7.01	65.20	3.25
Cottonseed Meal	91.8	37.01	16.52	12.58
Hominy Chop	88.9	7.45	55.24	6.81
Oats	89.0	9.25	48.34	4.18

From this table the following ratios have been calculated as illustrating the way in which alfalfa may be used in dairy feeding. It will be observed that the greater the amount of alfalfa in them the less is the amount of purchased protein in the shape of nitrogenous by-products:

Rations for twenty-four hours for dairy cows weighing 1000 pounds and in full flow of milk:

No. 1—Green Alfalfa, 50 lbs.; Corn Chop, 12 lbs.

No. 2—Alfalfa Hay, 18 lbs.; Corn Chop, 8 lbs.; Corn Fodder, 5 lbs.

No. 3—Alfalfa Hay, 17 lbs.; Corn Chop, 11 lbs.

No. 4—Alfalfa Hay, 18 lbs.; Corn Chop, 7 lbs.; Corn Silage, 20 lbs.

No. 5—Alfalfa Hay, 12 lbs.; Corn Silage, 40 lbs.; Corn Chop, 5 lbs.: Cottonseed Meal, 1 lb.; Gluten Meal, 1 lb.

No. 6—Alfalfa Hay, 12 lbs.; Corn Silage, 30 lbs.; Corn Chop, 6 lbs.; Gluten Feed, 3 lbs.

No. 7—Alfalfa Hay, 12 lbs.; Corn Silage, 35 lbs.; Corn Chop, 6 lbs.; Cottonseed Meal, 1½ lbs.

No. 8—Alfalfa Hay, 12 lbs.; Corn Silage, 20 lbs.; Corn Chop, 9 lbs.; Wheat Bran, 1½ lbs.; Cottonseed Meal, 1 lb.

No. 9—Alfalfa Hay, 10 lbs.; Corn Silage, 40 lbs.; Corn Fodder, 5 lbs.; Hominy Chop, 4 lbs.; Cottonseed Meal, 2 lbs.

No. 10—Alfalfa Hay, 15 lbs.; Timothy Hay, 5 lbs.; Corn Chop, 5 lbs.; Oats, 4 lbs.

No. 11—Alfalfa Hay, 20 lbs.; Corn Silage, 40 lbs.

GROWING ALFALFA IN MARYLAND.

Numerous attempts have been made in recent years to grow alfalfa in Maryland. For the most part these efforts have been failures, and the impression has been pretty generally formed that our soil and climate are not adapted to its growth. Some of the efforts have, however, succeeded, enough of them and in such widely-separated localities as to show clearly that the successful growing of alfalfa in this State is mainly a question of local soil selection. There is no doubt but that, with more experience in handling it and a better knowledge of the conditions it requires, there are in every county in Maryland thousands of acres which might be and ultimately will be put into alfalfa.

The long tap-root of the plant indicates its natural adaptation to a loose-textured, deep soil, free from standing water and affording an abundant supply of air for root-breathing. In such a soil the long roots penetrate to and draw upon supplies of food and water quite beyond the reach of other plants, so that it grows and flourishes in hot, dry weather where less deeply rooted crops suffer or die for lack of moisture.

On the other hand, where the rock comes close to the surface, or the water table stands but a short distance below, or where the soil is so dense the air moves through it with difficulty, the alfalfa is at a disadvantage. Its tap-root cannot penetrate the rock. It will not go into the water or beyond the reach of fresh supplies of air, and so it splits up, the plant trying to some extent to assume the habits of those native to such environment. The consequence is obvious. The native plants are more vigorous and the alfalfa is killed. A common report made by the alfalfa experimenters of last season was that the alfalfa came up well and grew beautifully till the rains came on, then the weeds got ahead and killed it.

The less adapted the soil is naturally to alfalfa the more necessary it is to have it free of weed seed when the alfalfa is sown.

The State of Maryland is divided by a line running approximately with the Baltimore and Ohio Railroad, into two distinct agricultural sections. North and west of that line the soils are underlaid with the rock from which they are formed, and change in character with it. As a rule they are of finer texture and contain more clay than the soils of the southern and eastern sections, and are hence better adapted to the growth of blue grass and surface-feeding crops. In this section of the State there are undoubtedly areas where alfalfa cannot be grown because of the too dense character of the soil and because of the underlying rock being too close to the surface. There are, however, large portions of it derived from coarse-grained rocks which are comparatively open and porous to a great depth, and on these alfalfa should find a congenial home. This is especially true of the so-called isinglass soils, which are not only of good physical condition but are rich in potash, which alfalfa particularly demands. It is in this part of the State that the live stock interests have been most developed, because the soil here is better adapted to hay and pasture grasses, but under present intensive methods of farming, pasturage is of lessening importance and soiling is taking its place. There is no crop which equals alfalfa for this purpose, and our farmers of the northern and western counties should promptly find out by observation and experiment which of their lands are adapted to this crop and at once begin its cultivation on as large a scale as possible. This is necessary if they would hold their own in competition with the West, and possibly, at a future day, with other portions of their own State. It is gratifying to know that already many of the progressive farmers of this section have turned their attention to alfalfa, and either at their own instance or that of the Station are already growing it with more or less success.

To the south and east of the Baltimore and Ohio Railroad, comprising Southern Maryland and the Eastern Shore, the soils are of a different character. They were formed of material transported from higher levels by the action of the water. They are consequently deeper than the northern and western soils, and though differing considerably among themselves in physical characteristics, contain more sand and gravel, the typical soil being sandy loam.

It is throughout this portion of the State that alfalfa will probably find its most favorable environment and be ultimately most extensively used. There are portions which are flat and lack drainage, but with these exceptions there seems to be no good reason why it should not be grown throughout the whole of Southern Maryland and the Eastern Shore.

One feature, of special advantage, is the fact that large areas of these sections are underlaid with marl. In many places this is at or near the surface, forming a calcareous soil which is particularly favorable to a heavy growth of legumes. When the marl is not near the surface it may often be dug on the farm and spread on the land at a trifling cost. Southern Maryland is especially rich in these marl deposits. The future for alfalfa in this portion of the State is bright indeed, and with its general introduction will come a new era of prosperity for the "lower counties." Stock farming would take the place of tobacco farming. The fertilizing elements of the soil would be concentrated at home instead of being shipped abroad. Larger crops would be raised. Soil improvement would take the place of soil exhaustion. Worn-out farms would be restored to their original fertility. Landed values would be raised, and new farms would be cleared from the "second-growth" woods that now encumber such large tracts. One effect of far-reaching importance would be the substitution of a permanent demand for high-class labor for the present intermittent demand for low grade.

The counties which are generally recognized as being the most prosperous are those which, according to the Census Reports, contain the greatest quantity of live stock. The counties of Southern Maryland have but to make use of the opportunity which now presents itself, and whose practicability has been demonstrated beyond peradventure, to become as noted for fine stock as they have been for fine tobacco. The demand for animal products is increasing every year, and the West cannot now supply it. Never were prospects so bright for the Eastern stockman. But if in stock-raising corn is king, alfalfa must be considered queen. It is under their joint rule that prosperity most surely awaits the progressive and thrifty farmer.

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AGRICULTURAL EXPERIMENT STATION.

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THE INFLUENCE OF PRESERVATIVES UPON THE FOOD VALUE OF MILK.

BY C. F. DOANE AND T. M. PRICE.

PREFACE.

The study of the influence of preservatives upon the food value of milk was undertaken by this Station because of the extensive and growing use which is being made of various preservatives in many parts of the country; and particularly in the milk supplied to the Baltimore and Washington trade.

The plan adopted in the experiments which have been conducted here was to study the effect of the principal preservatives upon the digestibility of milk. It would have been far preferable to have used young children in such work; but this was impossible for obvious reasons, and animals had to be resorted to. Young calves were selected for the experiments as it seemed probable that they would be more susceptible to the influence of the preservatives than any other animals available and then, too, they are easily fed and controlled. In using calves for this work it was, of course, with a full appreciation that they were not so sensitive in all respects as a human being, and also with a full understanding that there was a wide difference in some respects in their digestive organs as compared to man's. Nevertheless, it was assumed that a preservative which would prove to be harmful or which would make milk less digestible with a calf would certainly be unfit for use in connection with human beings and particularly for infants. Again, it was also considered at the outset that in case a preservative showed no effect with a calf it would not necessarily prove that said preservative could be added to milk to be used by children without causing harm.

The work which has been done by this Station was started in 1900 and has been carried through two years. The details of the plans, descriptions of the animals and methods of feeding, etc., is given in connection with the results as recorded hereafter.

Before giving the results of our experiments it will be of interest to give a history and brief resume of the work which has been done upon this same subject, together with the opinions of prominent physicians, many of which have been given to the public during the last few months and long after the experiments were begun by this Station.

The experiments which are reported in this connection were undertaken at the suggestion of the director of the Station and conducted by the authors, jointly. The analytical work was performed by T. M. Price and the results discussed and the bulletin prepared for publication by C. F. Doane.

INTRODUCTION.

The use of preservatives in foodstuffs and especially in Milk is one of the most important if not the most serious problem with which city health departments and State dairy and food commissions have to deal at the present day.

Almost all kinds of perishable products used as food are not only occasionally but habitually treated with some kind of preservative by irresponsible dealers and manufacturers. Salicylic acid is added extensively to all kinds of jellies, jams, and preserves sold on the markets as well as to beer and cider. Fresh and cured meats are treated with borax and boric acid. Formaldehyde is used in oysters, while fresh milk and butter is treated with borax, boric acid and formaldehyde.

Were these preservatives only occasionally used the matter would not be so serious or the problem of control so difficult; but there has been so little known of the character of the preservatives or their probable effect on the consumer that their use has gone practically unchallenged for so long that many of the, otherwise responsible, firms have adopted them as a necessity in order to be able to meet competition; and then, too, there seemed to be no reason to believe them harmful to the consumer. The manufacture and sale of preservatives has finally grown into a great industry and has become so well established that it will eventually require the entire power of the State to give it a check. A few cities and states have carried on a determined fight against the use of preservatives especially in milk and have met with more or less success. In a few cities the proportion of the milk treated with preservatives and offered for sale has been reduced to a very small figure. This is particularly true in some of the New England States, especially Massachusetts. Boston in particular seeming to have been unusually successful in its fight for unadulturated milk. It is believed that Wisconsin has succeeded as a State in reducing the use of preservatives to a minimum. Other cities and states have either made no effort to secure a pure food supply, or have expended their money and put their energies almost wholly in regulating the sale of oleomargarine, and seeing only that the requirements as to the quality of the milk were complied with. Nearly all of the more important cities in the country claim that a very small portion of the milk sold in their jurisdiction is treated with preservatives, but it is very difficult to determine whether they are giving facts as they know them, or simply give these favorable reports for the benefit of the city. Baltimore is very likely among the more lax cities in controlling her milk supply, and she has the reputation for being one of the best markets for preservative in the world. This is particularly due to the fact that many oysters are treated with preservatives, but it is also likely that a very large per cent of the milk sold to her residents during the summer months is kept sweet by some antiseptic. A prominent Baltimore business man who is probably in a position to know, estimated that fully 90 per cent of the milk sold in the city during the three summer months was of this character.

The use of what we now commonly call preservatives commenced at a comparatively recent time. The principle of antiseptics was not even partially understood thirty years ago. For a number of years after that the only antiseptics known were violent poisons, and of course could not be added to food intended for consumption. About the first time that the attention of the general public was called to the fact that food products were being treated with antiseptic was in 1886 when "Lancet," a London Medical Journal, protested against the use of "poisonous preservatives." This article was also the first to make known the fact that certain chemicals, not violent poisons in small quantities, could be used to preserve food, and, as there was no legislation to prevent their use and no known way of easily detecting their presence in foods, the traffic commenced to grow very rapidly. It is, perhaps, in the last eight or ten years that the industry has reached anywhere near its present proportions, and it is very likely that, notwithstanding public opinion and the efforts of a few cities to regulate or prevent the sale of foods preserved with chemicals, that their use is on the increase at the present time.

It is not surprising that the traffic in preservatives should have grown so rapidly and steadily from the fact that there always has been and always will be a growing demand for fresh foods of nearly all kinds. To keep many kinds of food products fresh until the poorer residents of our large cities have had a chance to consume them has always been difficult and comparatively expensive, while preservatives have proven to be relatively cheap, convenient, and effective.

There are four agencies for preserving in common use, viz: 1. Drying, 2. Canning, 3. Refrigeration, and 4. Antiseptics. Not all of these are applicable under all conditions and circumstances and unfortunately that which is probably best, especiallv for milk, is too expensive and cannot be had in all homes. Cooking and canning is applied to many vegetables and most fruits and also meat. But, while it keeps foods so treated over an extended period and is extensively employed, it is expensive. Refrigeration is the most desirable of all as it will keep most animal products, fruits and vegetables in their fresh state for a considerable length of time. But it is very expensive and except where it can be employed on an extensive scale the cost is practically prohibitive. The last of the four ways, is preserving by means of chemicals. Compared with refrigeration, they are very cheap in small markets; and they keep the preserved substance apparently in almost a perfectly fresh condition. In milk production, preservatives are the means to an end which would otherwise require an extra amount of work and some expense for apparatus. Were it not for the fact that the effect of the preservatives on the consumer was somewhat questionable they would, except for one thing which will be mentioned further along, be an unmixed blessing. There always will be an effort to find some substance which is known to be perfectly harmless to the human stomach and which will have the effect of arresting decay in meat and vegetables, though there are reasons for doubting if such a substance will ever be found. The preservatives now used for this purpose fall short of this in that while they are not positively known to be harmless in the quantities employed, there is a possibility that they might be injurious in some cases. This last fact seems to be entirely lost sight of by the manufacturers of preservatives and those who use them, and they claim that as they have never been proven to be injurious they should not be prohibited. But as both classes are financially interested, but little weight can be given to their opinions.

It is in the dairy business that preservatives have been most extensively used. The reasons for this are not hard to find. Milk is more quickly perishable than almost any other food. Under ordinary summer conditions the greatest care has necessarily to be exercised to get the milk into the hands of the residents of our larger cities in fit condition for consumption. When there is a surplus in the hands of the dealer he is at considerable expense and trouble to hold it over until the following day. To make matters worse, consumers are unreasonable in their demands as to the length of time the milk will keep after receiving it, and this when they have the very poorest conditions for keeping it. Preservatives obviate all of these difficulties to a great extent. The consumer does not trouble the dealer with complaints about the keeping qualities of the milk. Preservatives make it cheap and easy to keep a surplus for a considerable length of time. By using preservatives the producers of the milk are not forced to observe so closely the otherwise necessary laws of cleanliness, and they are not put to so much trouble and expense in cooling the milk quickly and thoroughly. This last fact is the exception which would prevent a harmless preservative from being an unmixed blessing under any circumstance. Preservatives have been called the lazy man's friend, and they are certainly made to be the friend of the filthy dairyman many times. One of the strongest arguments against their use by dairymen is that the milk can contain so much filth as to be absolutely unfit for consumption, and still be clean and sweet to the taste, because the preservative has covered up the presence of the undesirable properties.

It has been argued that partially spoiled milk is more injurious to invalids and children than the preservatives necessary to keep it in good condition. But there is a fact in that connection of which the physician and dairymen who have advanced that argument appear to have entirely lost sight. A sufficient quantity of preservative to keep the milk sweet indefinitely or even for a number of days is never used. Now, the dairymen, or most dairymen, will take just sufficient care of his milk to get it into the hands of the consumer in a fairly sweet condition. If he is allowed to use preservatives he does not put forth the same care as he would otherwise and consequently the milk is as far towards decomposition when it reaches the consumer as though no preservative had been added. Consequently, when the consumer gets the milk it has all the undesirable qualities of the milk not treated with the preservative plus the preservative which has been added. It is very likely that in the majority of cases where preservatives have been used for any length of time, approximately the foregoing conditions will be found. These conditions apply in a less degree perhaps to the city dealer as well, for in proportion to the amount of preservatives used he will neglect other precautions to keep his surplus from spoiling on his hands. The more preservative added to the milk the less ice is required.

MATERIALS USED AS PRESERVATIVES.

Borax, boric acid, formaldehyde, and salicylic acid are the preservatives used in milk and butter, salicylic acid being but seldom employed in this particular industry. But the farmer or milk dealer seldom knows the preservatives he uses under these names. In fact, the majority of them do not know that simple chemical substances are used for this purpose. They buy their preservatives under various fancy and suggestive names, such as, Iceiline, Glacialine, Freezene, or Milk Sweet, or one of the numerous other lot of names which are adopted to sell the material. These, however, have been found to contain one or a mixture of the foregoing substances, without exception. Usually they are in a very diluted form. The price varies with the seller, but they are never sold by regular so-called preservative manufacturers at as low a price as the chemicals used can be purchased. Some particular brands are sold for as much as eight times the cost of the original material. The U. S. Department of Agriculture has analyzed practically all the preservatives sold on the market in this country as well as obtained the information in regard to the prices for which they are sold.

The amount of preservatives necessary to add to milk has been determined with the pure chemical. For the various brands sold on the market the amount necessary would of course depend on the strength of the material. For formaldehyde, which is a gas and which is sold under the copyrighted name of formalin—this being a 40% solution of the gas in water, about one part of the gas to 40,000 parts of milk, or one part of the solution in water to 16,000 parts of milk has been found to be the minimum quantity. Borax and boric acid are advised to be used in the proportion of 40 grains to the gallon of milk, or about one part of the preservative to 2,000 parts of milk, as a minimum quantity. These proportions have been determined by the amount of each required to add about twenty-four hours to the length of time the milk will keep under ordinary conditions. This is supposed to be long enough to allow the milk to be in the hands of the consumer a reasonable length of time before souring. The longer the milk could be preserved, it is obvious, the greater would be the advantage of both producer and dealer. But any of the preservatives employed for this purpose are known to be violent poisons when taken in large quantities, and even the most unscrupulous dealers are afraid to add sufficient to prolong indefinitely the keeping qualities of the milk which could be easily done with advantage more than equalling the expense of material.

The manufacturers, as a rule, send out definite instructions as to what quantity of their particular preservative is required for a gallon or can of milk, though where it is advised to use one or two spoonfuls it is easy to see how the amount required for a spoonful might not always be the same with different persons. All manufacturers and most dealers know that in large quantities their preservatives are poisonous and they try to clear themselves of all responsibility by giving the direction as to quantity. In this they really admit that preservatives need to be handled with care or they may become dangerous to the consumer.

In the advice or general directions given as to the amount of preservative required to keep milk sweet for the necessary length of time it seems to be taken for granted that both the producer and dealer will take the otherwise necessary precautions to keep the milk in good condition, and will simply employ the preservative as a supplement to the use of ice to insure against any possible loss. The manufacturers of preservatives know that this is a short-sighted view of human nature. The amount of innocent looking preservative advised as sufficient to meet the requirements seems so ridiculously small to the user in comparison with the amount of milk treated that he thinks the addition of a little more can work no harm, so he relaxes his precautions of cleanliness and cold and adds more preservative.

Another abuse of the use of preservatives arises from the fact that the milk may pass through a number of hands before it is consumed. The producer adds preservatives in varying quantities to insure his milk reaching the dealer in good condition. The dealer is uncertain as to the amount of care the milk has had and is entirely ignorant of the fact that the producer has already used a maximum quantity of preservative, so he adds a liberal allowance to insure himself against loss and to save ice. Finally, the ignorant kitchen-maid has had experience with milk souring while in her care and adds preservatives to prevent undesirable criticism. In this way the milk is treated three times with preservative and if each has been particularly anxious that the milk should not spoil, a very large quantity may have been added. This may appear to be overdrawn or only a supposition, but there have been cases where it has been known to be the exact state of affairs, and analyses of samples of milk have shown such large quantities of preservatives that it could be accounted for on no other basis. For the milk to have preservatives added to it by both producer and retailer is a very common occurrence and in all likelihood occurs times without number in and out of the City of Baltimore.

QUANTITY OF PRESERVATIVE NECESSARY.

It is very doubtful if the amounts of preservatives specified as being sufficient for practical purposes has been placed sufficiently high. Experience at this Station would show that it required about double the amount ordinarily advised, to have any practical effect. We found that when boric acid was used in the proportion of 1 to 1,000 the milk would keep about twice as long as it would without the preservative. This work was done in the winter and the milk was allowed to stand at the regular room temperature. This temperature varied slightly from above 70 F. during the day to as low as 50 F. at night. At this varying temperature the check samples of milk remained sweet for from twenty-four to forty hours and the preserved samples from forty to sixty hours. Varying quantities of preservatives were tried but while boric acid 1 to 2,000 had a noticeable effect, it was so slight as to appear of no practical value. In the lots of milk treated with preservatives for our experiments in feeding calves it was noticed on several occasions that the milk had soured before it was fed to the calves, thirty-six hours after it was milked. This milk had boric acid 1 to 1,000 or borax 1 to 800 and was left in a room where the temperature varied from 70 F. during the day to 50 F. at night. In fact, this milk kept but very little better than the untreated milk. Judging from this experience we are of the opinion that preservatives necessarily have to be employed in amounts in excess of that usually advised for any practical benefits. We doubt very much if preservatives would be used in this minimum quantity by others than beginners as they would discover that it was doing them very little practical good. In our work with formaldehyde we added in the proportion of 1 to 10,000. However, this is about twice as much as would be required in practice, while it is very likely that the proportion of 1 to 40,000, usually advised, would be only about one-half as much as would be required for any practical good, or to increase, materially, the keeping qualities of the milk.

AMOUNTS OF PRESERVATIVES FOUND IN MILK.

The amounts of preservatives actually used is a matter of considerable interest. In this country there are very few recorded analyses made for the amount of preservatives present, the fact that it is present seemingly to have been the thing to determine. In 1899, a Commission was appointed by the British Government to thoroughly investigate the use of preservatives and the testimony brought out was published in full by the Government. Analysts, health officers, famous physicians and physiologists, were summoned before this Commission to testify and this mass of evidence secured is the most exhaustive of anything obtainable on the question. Among other things, a large amount of testimony in regard to the amounts of preservatives actually found in samples of milk was obtained from the public analysts, and some testimony brought out on this question is here given.

Dr. Bosley, a London analyst, testified that he had found borax added to the milk in the proportion of 1 to 1,000.

Dr. Walford, health officer of Cardiff, testified that he had found boric acid in milk at the rate of from 28 to 64 grains per gallon.

Dr. W. Williams, another health officer, testified that he had found as high as 210 grains of boric acid in a gallon of milk.

Dr. A. Hill, Medical officer of Birmingham, found as high as 126 grains of boric acid to the gallon of milk and had found formaldehyde in the proportion of 1 to 20,000. He had found boric acid as low as 5 grains to the gallon of milk and formaldehyde as low as 1 to 100,000. He thought the varying quantities were due to the ignorance of the user as to the amount necessary to keep the milk for the required length of time. It is very likely that some people who know that an overdose of preservative would have a bad effect, use less than the advised amount rather than more, at least until they find that the amount they are using has no effect, whatever, on the keeping qualities of the milk.

W. F. Lowe, a public analyst, said that he had found from 24 to 80 grains of boric acid to the gallon of milk.

W. B. Blyth, a public analyst, said that he had found a sample of milk with 320 grains of boric acid to the gallon.

Dr. J. T. Thomas, a country medical officer, said that he had found as high as 125 grains of boric acid to the gallon of milk.

The larger amounts of preservatives found in milk as testified to before the Commission is of course much more than is found in milk as a rule. They are exceptional cases. But it seems that to find as high as 100 grains of boric acid in a gallon of milk is not an uncommon occurrence. This is more than is needed to keep milk for a relatively long period, and that such a large proportion of preservative should be found is undoubtedly due to the ignorance of the user as to the effect of excessive amounts of preservative on the human system or as to the necessary amount to keep the milk for the necessary length of time. Or, it may be due in the majority of cases to the fact that preservatives have been added twice, first by the producer and then by the dealer who is in ignorance of the fact that some preservative has already been added.

PROPORTION OF MILK TREATED WITH PRESERVATIVE.

Another question which is necessarily of interest in connection with the use of preservatives is as to the amount of milk sold in our large cities that has had preservatives added. There is a great deal of difficulty in getting any accurate, or even approximate, figures on this point. The great majority of City Health Boards know little about this phase of the question, or are very reticent on the subject, refusing to give out the information they have at hand. When questioned, they simply said that very little or no preservative is used, giving no figures to prove their assertion.

The British Commission, before referred to, brought out testimony on this point as regards British communities. England has a very large number of what are known as public analysts who keep a pretty close record of the different problems relating to the food supply of that country and the figures they give should be fairly accurate.

Dr. Bosely, the London analyst before mentioned, said that as far as he could determine, about 50 per cent of the London dairymen used preservatives during the three summer months.

Dr. Walford, the Cardiff health officer, said that about 14 per cent of the milk sold in his jurisdiction was treated with preservatives.

Dr. A. Hill, of Birmingham, found 20 per cent of the samples analyzed to have been treated with preservatives.

Dr. S. Cameron, Health officer of Leeds, found 25 out of 49 samples of milk analyzed to have had preservatives added.

How the figures given by these men would compare with conditions in our own country and cities is difficult to determine, and it is unfortunate that our city health officers either do not know or hide the condition of affairs. One thing may be certain, that Americans are as quick to learn new things as are English people and if they could gain anything by the use of preservatives they are not ignorant of it. They may or may not be more scrupulous in their regard for the welfare of other people than are the inhabitants of other nations. The chances are that fully as much or more preservative is used in this country than in England, especially in southern cities.

The need of preservatives was pretty well brought out by the British Commission and is, with the question of the effect of preservatives on the consumer, the most important of the whole problem. If there was no particular need for preservatives, if the dairymen could, without any impractical expense, get his milk to the consumer in good condition, then there would be no particular need for experimental workers spending their time in trying to determine the effect of preservatives on the consumer. The traffic could be prohibited without doing any great injustice to anyone concerned. But if there is a need for preservatives on the part of the dairyman, if the problem of shipping milk to our large cities and having it reach the consumer in good condition is a grievous one, then the question of the preservatives should be taken into consideration. Should preservatives endanger human life they should be prohibited, while if they do not there would be no harm in allowing the producer and dealer to add a sufficient quantity to insure their stock in trade keeping in good condition for a reasonable time.

The question is a complicated one and it is not the intention to enter into the needs for a preservative at any length in this bulletin. The Station is engaged on the problem of keeping qualities of milk and a report will be published later. This phase of the subject was pretty thoroughly discussed before the British Commission and, as was the case with every other branch of the subject there was a variety of opinions expressed. A number of dairymen supplying milk for the poorer quarters of cities were of the opinion that it was impractical if not impossible to supply milk to their trade without preservatives. On the other hand, dairymen shipping milk into London from distances greater than 100 miles claimed that they never used preservatives and had very few complaints from customers because their milk did not keep well. It is very likely that the tenement districts in our cities supply as difficult problems for the milk trade as does London, as we have a warmer summer climate. But, on the other hand, there are dairies supplying pure milk to such a trade, and what can be done in one case by one man, can certainly be done in a similar case by another.

Dr. Harold Faber, Commissioner for the Danish Government, said that in Denmark, salicylic acid and boric acid were entirely prohibited in food products, and that the great Danish dairy industry felt not the least inconvenience from this prohibition. He said that Copenhagen received a large part of its milk supply from a very long distance but not the least trouble had been experienced in getting good milk for all consumers. It might as well be noted here that the problem in this country is a little more difficult, from the fact that our summer climate is much warmer than any of the northern European countries, and it is very likely that milk is shipped a much greater distance in this country than in any country of Europe. On the other hand, we may have a few advantages not found by others. It is not putting it too strong to say that it is practically certain that milk can be sold to all classes in our large cities without the use of preservatives. The systems of supplying the poorer quarters might need to be regulated by the city authorities, but it is entirely possible for the producer to deliver milk to the city dealer practically in as good condition as when it was drawn from the cow.

THE EFFECT OF PRESERVATIVES ON THE CONSUMER.

It is a well known fact that all of the chemicals employed as preservatives in commercial dairy products up to the present time may well become violent poisons if taken internally in sufficient doses. Their effect, however, in the quantities in which they are commonly used in food products is a question of serious dispute. Serious because on it ultimately hinges the decision whether their use is to be, or should be, allowed. Borax and boric acid as well as salicylic acid are frequently employed by physicians in certain kinds of diseases. Until within the past two or three years the dose given by the pharmacopae was from fifteen to thirty grains per day of boric acid. But the amount has been reduced to from five to fifteen grains per day as the former dose was found to do more harm than good in some cases. It seems that many physicians still hold to the original dose, believing that it does not prove harmful.

In considering this question there are a few things which it seems reasonable to take into consideration. The fact should not be lost sight of that milk, especially among city people, is consumed by infants and invalids more than by healthy adults and consequently for obvious reasons, the effect of the preservatives on healthy persons is not comparable with the effect it might possibly have on more susceptible subjects. One particularly grievous error seems to crop out in the opinions expressed by medical men. They calculate or determine by experiments the amount of preservatives mature persons can consume without injury, and then give all their opinions from this standpoint. Another fact is that preservatives are mostly used during the hot summer months when the children of the poor districts are already troubled with dysentery and other bowel troubles and have all they can do in many cases to maintain life. The possible effect of preservatives on that class should be the consideration, rather than the effect on the healthy person.

Another stand taken by certain men which seems to be very peculiar in view of the fact that the preservative problem has to do with human health, is that as preservatives have never been proven to be harmful they should not be condemned. A number of physicians and scientific workers have taken this ground in arguing that milk dealers should not be prohibited from employing preservatives in their business. It seems that just the reverse should be the case. Preservatives are known to be harmful in large doses, let those who desire to add them to food products furnish reasonable proof that they are harmless in all cases and with all classes of people.

Two general ways of determining the effect of preservatives on the system of the consumer are open to those who desire to pursue such investigations. One is by experiments in feeding preservatives either to the human subjects or to animals, the effects of which could be compared with human beings The other is collecting all the information and opinions obtainable from physicians, physiologists, and others qualified to give information as to the probable effects of the chemicals used as preservatives on the different parts of the animal organism. The feeding of preservatives to animals and man to note their effects has been carried out in a large number of instances with more or less success. Especially has the work been very thorough as regards animals. Adult human beings have been given preservatives either as an experiment or as medicine in a number of cases; but it is very easy to imagine that the information available in regard to the effect of preservatives on infants is practically eliminated, owing to the extreme difficulty of obtaining children for such purposes no matter how desirable it may be that such experiments should be made. Of course, no mother would ever consider, for an instant. the use of her child for such a purpose, and physicians in charge of children's hospitals and foundling asylums have conscientious scruples against allowing the work to be done with any of their charges, or they are afraid of public opinion. They may or may not have just ground for their stand, but it is very likely that many such institutions consume a large amount of preserved milk without being aware of what they are using, especially when the lack of funds makes it impossible to obtain milk for the children from an unquestionable source.

A number of mature men have taken preservatives systematically for an extended period to test its effects. Borax seems to be the one that has been mostly used in such trials. In one case, children under five years of age were fed different preservatives as an experiment, one of the children being sickly. While this was undoubtedly the most valuable piece of work that has ever been carried out along this line it is very doubtful if the results obtained are comparable with the possible results with infants under six months of age receiving the same preservative.

For a large part of the knowledge of the effect of preservatives on the human system, the London "Lancet" deserves a great amount of credit. This journal was the first to call attention to the use of preservatives and has kept in touch with the subject continually. In 1899 the "Lancet" addressed inquiries to the leading physicians and physiologists of that country, asking for information and opinions on the effect of preservatives on the consumer. In addition to this the British Commission gathered a great amount of testimony on the same point. It was the Commission that authorized the carrying out of the experiments with children. In American medical publications very little can be found on this subject other than of a general nature and American scientists seem to have had very little to do with the question in any way. A feeding experiment with dogs was carried on and some artificial digestion work has been done but this seems to be all. Even German literature which deals extensively with almost every subject of a scientific nature has passed this by and very little experimental work with preservatives has been done by Germans. We have had for our reference work on this subject access to the Library of the Surgeon General of the U. S. Army, which is without doubt the most complete medical library in the country.

OPINIONS OF PHYSICIANS AS TO THE EFFECT OF PRESERVATIVES.

Opinions of physicians and health officers, based on experience other than experimental, will be considered first. The great majority of medical men seem to agree that with a healthy mature person very little harm ever results from the use of preservatives for two reasons. Very little preservative food is eaten by healthy adults, at least not continuously, and the healthy mature stomach seems to be not easily affected by the quantities consumed. However, in a number of instances cases are reported where borax or boric acid were used in certain diseases and the continued use led to undesirable conditions. In these cases the medical dose sometimes slightly increased was given. Some uncertainty was expressed even by men who favored the use of preservatives as to their possible effects when taken in amounts greatly in excess of the medical dose. In the case of children, especially infants, and with individuals confined to a milk diet, the opinion was practically universal that in comparatively large amounts they would be extremely dangerous. The greater number believe that preservatives in any quantity for infants and invalids would not be advisable, but there seemed to be an honest difference of opinion on this point, some thinking that the preservatives would be less harmful than poor milk.

Dr. Pavy, in his reply to the request of the "Lancet" said that because there was no tangible evidence of injury to health from the use of preservatives he did not consider that our knowledge is sufficient to say that the indiscriminate use of antiseptics will not produce injury. By the use of antiseptics it is the vendor and not the consumer who is benefitted, as articles which are not fresh are made to appear so, and to continue this was an injustice to the consumer and the seller of the fresh article. He said that most articles when properly made and handled did not require the addition of an antiseptic; and when the antiseptic was added the article was not sold on its merits. He said that justice to all concerned required that the presence of antiseptics be plainly stamped on the article sold so the buyer and consumer would not be deceived.

At the time this inquiry was set on foot by the "Lancet" it was generally believed that a law forcing the users of preservatives to stamp the nature and amount of preservatives on the article sold would be sufficient to regulate the traffic. It seems, however, that in a very short time after this there was a change of opinion, and absolute prohibition of preservatives was thought by the majority to be the only remedy. Dr. Pavy's opinion is interesting as it takes up the argument often urged that as preservatives have never been known to have any harmful effect there is not just grounds for condemning their use. He takes the other, and what would appear to be the more just view, that until they have been proven harmless they should be prohibited, or at least that the consumer should know what he is eating.

Dr. F. J. Allen, Professor of Physiology in Mason College, Birmingham, England, in replying to the same inquiry by the "Lancet," said that whatever antiseptic may be used there is always sufficient present to exert an influence on the organisms which are present, and this effect can hardly be beneficial to the tissues of the alimentary canal. Even the disinfection of the contents of the canal is a doubtful blessing, as germs which may be desirable may be destroyed with the others present. He goes on to state that while one or a number of doses of boric acid may be harmless or beneficial on occasion, its continued use in almost every article of diet may have an entirely different effect.

Dr. G. Simms Woodhead in his reply said that it was hard to give a definite opinion on the subject, but while the preservative may be entirely harmless in ninety-nine cases the hundredth case would be seriously affected.

These two, Drs. Allen and Woodhead, take up two important points, that of the extended use of the preservative being the first. It is on this point where the most work of the experiments carried out have been rather weak as the periods during which the preservatives were given extended at the farthest only a very few weeks, while in actual practice the consumer of preservatives may take it for months, or even a great part of a life time; in which latter case the preservative might well have the effect that some harmful occupation have on men who engage in them, such as working in flouring mills, rock drilling or ice factories. The person seems healthy for a number of years, and the only means there is of telling that the occupation in question is harmful is by the statistics showing the comparative length of life of those doing such work. The consumer of preservatives might have a few years subtracted from the latter end of his life. The other important point touched on by Dr. Woodhead is that while the preservative might be entirely harmless in many cases, there might be an occasional case where it would have just the opposite effect. Scientific workers are often prone to regard human life much as they would that of an animal, and consider that an occasional evil result, even though it may involve a life, makes very little difference in the general results.

There are some exceptions which might be taken to those objections which will be noted.

Dr. T. Lanton Brunton, in his reply to the "Lancet's" inquiry, said that one must remember that poisons are actually formed by the decomposition of food products, and the question is whether the antiseptic of the products of decomposition are the most harmful. He said that his own belief is that the antiseptics are the least harmful of the two, but this is a point on which there is considerable divergence of opinion. He states further, however, that when antiseptics are used the amount and nature should be distinctly stated. Dr. Brunton,s statement is illustrative of the argument used in favor of preservatives. There were many others replied to the "Lancet's" inquiry, but these given are representative and are about the proportion of those in favor of and against preservatives.

Among others replying to the "Lancet's" inquiry, Dr. W. D. Halleburton mentioned a case where it seemed to be the general opinion that preservatives in milk had seriously affected some children.

Dr. A. Hill, before mentioned, said in his testimony before the British Commission that as far as he could determine the outbreaks of diarrhoea in Birmingham were due, in a measure, to the presence of preservatives in the milk consumed. In illustrating a point he said that a person might easily be eating in his foods as high as fifty grains per day of boric acid and then as had been known to happen a physician might add a further thirty grains to the amount as medical treatment, without knowing the patient had already taken a large amount in his food.

Dr. S. Cameron, before mentioned, gave as his opinion to the Commission that he thought it entirely probable that numbers of the cases of diarrhoea during the summer months in Leeds were due to preservatives.

Dr. Mann, of Owens College, Manchester, referred to a case that had come under his notice in which a child was suffering with a persistent attack of diarrhoea. The milk was finally analyzed and was found to contain boric acid. It was changed and the child immediately commenced to improve.

Dr. Howard Jones told the Commission of a case coming from New York in which a physician was treating a lady for dyspepsia and could make no headway against the disease until he found the milk which he had prescribed as a diet contained boric acid. It was changed and she immediately commenced to recover.

Dr. R. B. Wild said that while he had taken very large single doses without bad effect he had found that when the doses were repeated it caused trouble and he had found the same to be true in many cases with his patients. He felt sure that there were many cases where the presence of boric acid in milk could not help having a harmful effect. Dr. Hanford said that in his own practice he had known cases where thirty grains per day of boric acid had proved so injurious that it had to be discontinued though some could stand much larger doses. He mentioned one particular case where a child seven months old was having a persistent attack of diarrhoea which refused to yield to treatment until the milk which was found to contain thirty grains per gallon of boric acid was changed, when there was immediate improvement.

Dr. Robert Bell said that he had had considerable experience with borax in his practice and had never seen any evil results. He mentioned one man who had taken thirty grains per day for eighteen years without any noticeable evil result. He thought boric acid did more good than harm and recommended its use in milk.

Dr. Thomas Bond said he had prescribed boric acid in large doses without any undesirable results and he gave it as his opinion that forty grains to the gallon could be added without injuring infants raised on a bottle.

Dr. J. T. Thomas, a county medical officer, related some experience at New Port, in which a number of children were suffering with diarrhoea and he prescribed boric acid, the children became worse under the treatment and many of them died. He followed this up with inquiries and analyses and found that the milk had been treated with boric acid. He then experimented on himself and found that the boric acid produced nausea and general debility. In the case of the children, he said that not one that received milk from another source was sick while a very large per cent were sickened by the preserved milk. He protested against preservatives being added to milk supplied to the poorer districts, as the greater part of it was consumed by infants and invalids who were the least able to withstand it.

Dr. J. R. Kaye, a health officer of Yorkshire, prepared some tables for a given district in which the infant mortality, as well as the total mortality per thousand, in four periods of five years each, from 1878 to 1897 inclusive. The following table gives the result of his investigations:

TABLE I.

		Number of deaths among infants.
1st period,	1878 to 1882 inclusive,	142
2nd period,	1883 to 1887 inclusive,	143
3rd period,	1888 to 1892 inclusive,	146
4th period,	1893 to 1897 inclusive,	152

During the same time the general death rate had decreased owing to better sanitary conditions and medical knowledge. He said that he believed that the greater infant mortality was due to the use of preservatives in a large measure, if not entirely so. And one evidence of this was that the increase had taken place entirely in the summer months. There are a few circumstances which would make it appear that Dr. Kaye had grounds for his suspicion in regard to preservatives being the cause for the increased death rate. It is during the last two periods of these twenty years included that the use of preservatives have increased the most rapidly and it will be noted that the greater increase in the death rate was during the last two periods. The medical knowledge in regard to the care of infants has at least kept pace with medical knowledge in its relation to mature persons, and as the death rate among adults had decreased during this same time one would naturally suppose that the same would be true among infants. On the other hand it is very likely that many physicians would explain that the increased death rate was due in part if not in whole to certain changes which have come in the last few years in the caring for or feeding of infants. It is very likely that many more children are raised on cow's milk at the present time than twenty years ago or such at least is the case in our own country, and it could likely be affirmed that this is the cause of the increased death rate.

Many other statements made before the British Commission were called into question by other scientists and physicians but the statement of Dr. Kaye has never been disputed as far as we have been able to determine. If he is right in his supposition and assertion that preservatives are the cause of the increased death rate, it is the strongest argument ever advanced against their use. If he is wrong it was time ere this that some explanation had been made or some other cause offered in explanation of what his table would show to be the condition.

A very interesting statement made before the commission and one which has been widely commented on was by Dr. M. K. Robinson, Health Officer for East Kent. He related the case of an attack of serious illness of the inmates of a religious house.

Five out of seven of the inmates were attacked within a short period and suspicion was at once directed to the milk as the five sick ones used the milk and the other two had not. An inquiry showed that the cook had added an indefinite quantity of glaceline, made of boric acid, to the milk and that the dairyman supplying the milk had also employed boric acid as a preservative. Five fowls were feed on the remainder of the milk which had been made a blanc mange and all died, four other fowls eating a smaller quantity were made very sick with diarrhoea and loss of appetite. An analysis was made of the contents of the dead fowls for ptomains but none were found. A large proportion of boric acid was found, however. A very thorough investigation of every possible cause of the sickness was made and it seems that the milk was the only thing found that could account for it. This same witness said that there was a great outbreak of diarrhoea in Dover at about the same time, which from investigation he considered had been caused by preserved milk.

The statement in regard to the inmates of the religious house being poisoned by boric acid and the killing of the chickens by the same milk aroused a great amount of criticism on the part of those who believed that boric acid was harmless; and the correctness of the conclusions reached as to what had caused the death of the fowls and the sickness of the sisters has been questioned even by those who are opposed to using preservatives.

Dr. Oscar Liebreich a German Professor (Lancet, Jan. 6, 900, P. 13.), carried on some experiments to determine the quantity of boric acid required to kill mature chickens. He gave the chickens experimented with a porridge made from milk to which had been added boric acid at the rate of 500 grains to the gallon of milk. This was fed for a number of days without any noticeable evil results. He then fed each chicken one grain per day of the boric acid with the same result. - Liebreich thought that the poisoning was more likely due to ptomains. Dr. Robinson replied in the "Lancet" reiterating his previous statement that the sisters and the chickens had all shown signs of boric acid poisoning, and that the food made from the milk had been analyzed for ptomains which could not be found. Robinson stated that he did not believe that the experiments made by Liebreich were conclusive. It is a hard matter to decide who was correct in their conclusions. There can be no doubt that Liebreich fed the chickens under experiment as large proportion of boric acid as they would have had in the milk. On the other hand, his experiments may not have been extensive enough to warrant conclusions In addition to these experiments with chickens Liebreich made some tests, with animals, as to the effects of boric acid upon digestibility.[1]

Analysis for ptomains were made of the food which sickened the sisters but it seems to be well understood that such analyses are often very unsatisfactory. On the other hand, there have been very few even suspicious cases of ptomain poisoning in sweet milk, though it is comparatively frequent in ice cream. Milk turns sour too quickly for ptomains to form. This case of the sisters and the chickens becoming sick from eating the milk is suspicious, but in the present light it will simply have to be set down as such, the experiments of Liebriech and what practically amounts to an experiment in the case of the poisoning of the sisters being so opposite in results.

A. G. R. Foulerton (Lancet, 1899, p. 1427) along with a report on some experimental work conducted by himself and others, comments on

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FOOT NOTE [1] It is said that Liebreich was employed by manufacturers of borax to perform these experiments and for that reason some people have discredited his results and opinions; yet, as there was a distinct understanding that the results were to be published no matter whether favorable or unfavorable to borax, most people, who are in a position to judge, deem the conclusions perfectly honest.

the effect of preservatives when taken by man. He considers that an adult will consume no more than one-half pint of milk with his regular diet. If this milk contains boric acid in the proportion of 1 to 2,000 and no other preserved food is eaten, the amount of preservatives taken would become so diluted in the stomach as to be perfectly harmless. But, he adds, with children and invalids whose diet consists entirely of milk it would be an entirely different matter and the chances are that the preservatives would prove injurious. He says that the medicinal dose for a child is three-fourths grain and that even where the preservatives is added to the milk in the recommended proportion of 1 to 2,000 the child consuming one-fifth gallon of milk per day would be taking seven grains of the boric acid.

Foulerton gives four cases where he thought there could be no reasonable doubt that boric acid used as medicine had proven to be injurious. It produced in one man receiving thirty grains per day a very irritable rash which appeared or disappeared as the acid was or was not given: With a middle aged man receiving sixty grains per day a rash appeared, followed by the falling out of the hair and the enlargement of the salivary glands. With another patient vomiting, headache, and dryness of the skin followed irrigation of the rectum with a solution of boric acid in water. Foulerton concludes that the amount of boric acid taken in a total diet of preserved milk would be as much as had been known in some cases to cause serious toxic effects, while an infant receiving a greater proportionate amount would be at least as likely to be affected.

Foulerton then discussed the action of formaldehyde on the living tissue. He says that it has not been used as an internal medicine to any extent except as a throat spray in the proportion of from 1 to 500 to 1 to 2,000 in which proportions it will sometimes cause vomiting. He says that para formaldehyde, and urotropin, much like formalin, have been used as internal medicines without serious results.

ARTIFICIAL DIGESTION OF PRESERVED FOODS.

A number of chemists have carried on experiments on the artificial digestion of preserved food-stuffs and it would seem that sufficient work had been done along this line to thoroughly exhaust the subject, were it not that in a few instances the results have been so varying as to render the actual effect of preservatives on artificial digestion a little doubtful.

R. A. Cripps, (Analyst, 1897, p. 182) tried the effect of boric acid in solution on amolytic, proteolytic and milk curdling ferments. The boric acid was used at the rate of 1 per cent, .5 per cent, .2 per cent, .1 per cent, .05 per cent, .02 per cent, and .01 per cent. He found that even with the stronger solution there was no noticeable effect on the action of the ferments.

H. Leffmann, (Analyst 1890, p. 102) after a number of experiments concluded that neither boric acid nor borax interfered with proteid or starch digestion. He found that salicylic acid interfered with the digestion of starch but not with the digestion of proteids.

A. Bach, (Chem. Centrall-Blatt, 1897, p. 420) found that an aqueous solution of albumin treated with formaldehyde could not be precipitated by heat, and was more difficult to precipitate by 95 per cent alcohol. The proportion of formalin added was not stated.

H. A. Weber, (Jour. American Chem. Soc. 1902, p 4) conducted a number of experiments to determine the effect of different preservatives on the digestion of starch by saliva. He found that at the rate of 1 to 420 salicylic acid completely stopped digestion for an hour. In the same proportion borax retarded action. At the rate of 1 part of preservative to 840 parts of starch salicylic acid retarded digestion slightly and borax retarded digestion very much. At the rate of 1 part to 1050, salicylic acid had no effect and borax had considerable effect, and the same is true of one part of preservative to 2,000 parts of starch solution.

In the "Lancet" for 1899, p 1427, A. G. R. Foulerton publishes quite an extensive article on the effect of different preservatives on artificial digestion. He experimented with borax, boric acid, and formaldehyde and along with a report on his work gives the experiments conducted along the same lines by a number of other men. Foulerton found that boric acid in the proportion of 1 to 2,000 favored the action of saliva, while borax interfered with the action of the same ferment when used in the same proportion. He found that boric acid in the proportion of 1 to 200 still favored the action of saliva. Borax 1 to 2,000 was found to have a decidedly favorable influence on the pancreatic digestion of cooked beef, while boric acid in the same proportion had decidedly the opposite effect. When beef was treated for twenty-four hours with a mixture of boric acid and borax in the proportion of 1 to 2,000 its digestibility was decreased about 10 per cent. In milk treated for the same length of time with the same proportion of the mixtures of borax and boric acid no effect could be noted.

Formaldehyde was added in the proportion of one part of the gas to 40,000 parts of the food, Foulerton assuming that this would be about the proportion of this preservative used under ordinary conditions. He found that in this proportion it interfered with the digestion of proteids a little less than 4 per cent, and that it also had a retarding effect on the digestion of starch. He found that it did not interfere with the rennet coagulation of milk. Formaldehyde added in the proportion of 1 to 50,000 to beef for twenty-four hours before digestion made the beef 10 per cent less digestible. The caesin of milk treated for the same length of time was made 6 per cent less digestible.

Chittenden found that boric acid in the proportion of 1 to 2,000 slightly interfered with the digestion of dried blood fibrin, but in the proportion of 1 to 1,000 it favored its digestion. Borax in the proportion of 1 to 2,000 favored the digestion of coagulated egg albumin.

Mayberry and Goldsmith, (Chem. Centrall-Blatt, 1898,-69) found that boric acid in the proportion of 1 to 2,000 interfered materially with the digestion of blood fibrin, the effect decreasing as the proportion of the acid was increased. This fact, that in some instances at least, preservatives in comparatively small proportions seem to have a greater effect in some ways, as shown by the results of Mayberry and Goldsmith, is certainly very peculiar. The same result is noticed in the experiments of Dr. Annette in feeding formaldehyde to young kittens.

Bliss and Novy (Jour. of Experimental Med., 1899, IV, p. 74) experimented with formaldehyde in milk in the proportion of 1 to 2,500 and found that the prolonged action in this proportion on caesin rendered it more difficult to digest and to coagulate with rennet. In smaller proportions it has no effect.

Rideal and Foulerton (Brit. Med. Jour., 1900, II, p 2) found that when formaldehyde was added to milk in the proportion of 1 to 50,000 commercial pancreatin digestion of the caesin was injured 3 per cent. In milk to which the formaldehyde had been added for some time before, only about 95 per cent of the caesin was digested.

It is hard to arrive at any definite opinion from results obtained by these different workers. Cripps and Leffman concluded from their work that neither borax nor boric acid interfered with starch digestion. Weber and Foulerton concluded that borax interfered with starch digestion very materially, and Foulerton concluded that the rate of 1 to 2,000 boric acid favored the digestion of starch.

Cripps states that boric acid in all proportions has no effect on the digestion of proteids and Leffman agrees with him in his conclusion. Foulerton concluded that boric acid 1 to 2,000 interfered with digestion of cooked beef, while borax in the same proportion favored it, and a mixture of both acting through a number of hours interfered as much as 10 per cent. Chittenden agreed with Foulerton that borax 1 to 2,000 favored the digestion of proteids, while Mayberry and Goldsmith agree with Foulerton that boric acid 1 to 2,000 interferes with proteid digestion and they agree with Chittenden that this effect diminishes as the proportion of acid is increased.

From these conclusions by different men the effect of borax and boric acid on the digestion of starch is left in doubt, while it would seem that proteids are slightly affected. About all that can be said in regard to formaldehyde is that when used in very strong solutions it has the effect of hardening certain proteids and likely renders them more difficult to digest.

It is well recognized, however, that artificial experiments are not as valuable as digestion experiments with animals to which the food experimented with is a natural means of sustaining life. There are elements which enter into animal digestion which cannot be duplicated in the artificial process. A number of experiments have been conducted with animals to determine the effect of the common preservatives on the digestibility of the food.

EXPERIMENTS WITH ANIMALS.

As milk is the food most often treated with preservatives, or at least is most often considered in that connection, it is possible to experiment with a number of different classes of animals. Kittens, dogs, pigs and calves have been used for this purpose as well as in one instance, young children. The children were, of course, the most desirable subject for it is the effect of preservatives on children and invalids that we are most interested in. But it is obvious why such subjects would be hard to obtain however desirable it might be to experiment on them in this kind of work.

In a number of cases the physiological effect of the preservatives was considered along with the effect on the digestion of the food treated, and in other cases the physiological effect alone was considered. As it is difficult to separate these two features, considering the way the work was done, they will not be separated. One feature of the physiological effect has already been considered, that part which relates to the effect of the preservative, especially borax or boric acid, when used in medicinal treatment. And the evidence of one physician was also brought out that according to his best knowledge the boric acid used as a preservative had in one instance come near to causing the death of a number of inmates of a religious house. From all the evidence at hand it seems that borax or boric acid will in certain cases cause unfavorable symptoms when used in medicinal dose. And from the evidence it is also relatively certain that in the majority of cases borax or boric acid does not have this effect.

Chittenden and Gies, (American Jour, of Phys., 1898) carried out experiments with three dogs which were first brought to a state of nitrogen equilibrium or, where the amounts of nitrogen eaten and excreted were practically the same. In the first experiment the dog was given a constant diet for twenty-seven days. For the first nine days the dog received no preservative. The succeeding nine days the dog received five grams of borax per day, this being 6 per cent of the total food, both solid and liquid, eaten by the animal. The last nine days of the experiment the dog received no preservative. The amount of faces and urine were determined daily and daily analyses were made of both for nitrogen. The following table shows the amounts of nitrogen taken with the food and excreted:

TABLE II.

Period.	Nitrogen in food eaten, grams.	Nitrogen in fæces, grams.
1st, 9 days	88.33	2.12
2nd. 9 days	90.12	3.92
3rd, 9 days	89.88	3.62

Table II shows that there was slightly less nitrogen excreted in the faeces during the first period when no preservative was given than during the second period when the preservative was fed. This is usually considered as evidence that the food is less digestible for some reason. The dog gained slightly in weight during the period it was receiving the borax as well as the other periods.

The second dog was dieted ten days without preservatives. One gram of boric acid was then given for four days, 1. 5 the succeeding three days, and two grams for the following three days. No preservative was given for the following ten days. The total weight of faeces and urine were determined as before and daily analyses were made for nitrogen. The following table gives the nitrogen in the food eaten and in the faeces;

TABLE III.

Period.	Nitrogen in food eaten grams.	Nitrogen in fæces grams.
1st, 10 days	61.44	3.20
2nd, 10 days	62.08	3.94
3rd, 10 days	61.94	3.94

This Table shows, as with the first dog, that there was a noticeable increase in the nitrogen of the faeces during the period that boric acid was fed. This increase seems to hold over the third period when no boric acid was given. It is questionable if this could be due to the preservative given during the second period.

In the third trial the feeding was continued over a period of 56 days, the time being divided into seven periods of eight days. In the first period, no preservative was given. In the second period, borax was given in doses ranging from two to five grams. This was followed by a period without preservative. In the fourth period, boric acid in doses of from one to three grams were given. The fifth period no preservative was given, then borax was again given, this time in doses of from five to ten grams.

The following table shows the amount of nitrogen in the food and the amount in the faeces;

TABLE IV.

Period.	Kind of Preservative.	Nitrogen in food, grams.	Nitrogen in fæces, grams
Ist. 8 days	None	52.16	1.42
2nd, 8 days	Borax	50.89	2.18
3rd, 8 days	None	51.00	1.85
4th, 8 days	Boric acid	51.20	1.82
5th, 8 days	None	51.25	1.47
6th, 8 days	Borax	51.15	2.74
7th, 8 days	None	51.17	2.09

During the period that the dog was receiving the preservatives from five to fourteen grams more of undigested fat were found in the faeces. With this last dog as with the others considerably more nitrogen was found in the faeces the second period than when no preservative was given; and the nitrogen in the faeces again increases when borax is again given the animal in the sixth period. Judging from these three experiments the preservative used certainly has some influence on the digestion of the proteids and it would seem that it also does on the fat.

Dr. Oscar Liebreich, Professor of the University of Berlin (Vierteljahrsschrift fur Gerich Med., 1900) fed a dog in three periods of ten days each. The first period no preservative was given. In the second period the dog received the same amount of food and 2 grams per day of borax. In the third period no preservative was fed.

The following table shows the amount of nitrogen eaten and excreted in the faeces:

TABLE V.

Period.	Nitrogen in food, grams.	Nitrogen in fæces grams
1st, 10 days	87.49	2.30
2nd, 10 days	87.49	3.13
3rd, 10 days	87.49	2.57

It would certainly appear from these results that the borax had a marked effect on the food eaten by the dog, rendering it less digestible.

Liebreich fed borax and boric acid for an extended period to three dogs to see if these preservatives had any effect on the gain in weight. One to three grams dissolved in water was fed to each dog, the dog weighing from twenty to thirty pounds each. Two of the dogs receiving the boric acid gained in weight while the other neither gained nor lost.

Liebreich fed three rabbits weighing 1,300 grams each .1 gram each of boric acid dissolved in water. Two of the rabbits gained steadily in weight throughout the twenty-four days that the feeding was continued. The third rabbit gained until the last few days when it lost somewhat in weight.

Three guinea pigs were also fed .5 gram boric acid dissolved in water. The feeding was continued for ninety-five days, and all the pigs fed gained in weight slightly during this time.

Liebreich concluded from his experiments that neither borax nor boric acid in the proportion they were ordinarily used for preservatives were detrimental to health. If we were to judge from his experiments with rabbits and guinea pigs and from his work to determine if the preservatives had any effect on the gain in weight of dogs his conclusions could not be questioned. But judging from the results of his digestion experiments there was a decided difference in the digestibility of the food given in favor of the periods when the animal was receiving no preservatives. It was for carrying out these tests it is claimed Liebreich acknowledged he was doing the work for the borax dealers for a large sum of money. This may or may not have influenced him to lose sight of his digestion experiment with the dog in giving his final conclusions on the work.

The British Commission appointed to investigate the preservative question authorized the carrying out of some experiments with young pigs in which the feed was treated with formaldehyde and boric acid, in comparison with other pigs receiving exactly the same ration but no preservative. The feed given in all cases was barley, oat or wheat meal made into a paste with water. In the trials with boric acid eight pigs about two months of age were used. These were divided into four pairs each pair being as nearly alike in every respect as possible and receiving the same quantity of the same kind of feed, except that one received boric acid at the rate of about 1 to 800 of the total food eaten. Each pig was kept in a separate pen and each was weighed about every seven days, the experiment lasting 64 days. The four pigs receiving boric acid gained 184 pounds in the 64 days and the four fed in comparison gained 190 pounds, a slight difference in favor of the pigs not receiving the boric acid, but hardly enough to consider. One of the pigs receiving the boric acid scoured badly for a while and failed to make satisfactory gains and was left out of the calculations. But the scouring is rather unusual and may have been caused by the acid. During the last twenty days of the experiment the manure from one pair of the pigs was collected and analyzed to determine if there was any radical difference in the amounts of nutrients digested, but the analysis showed no difference.

Six pigs were used for the trials with formaldehyde, divided into pairs as before. The pigs received from 2 to 4 cc of the 40 per cent solution of formaldehyde, or about 1 to 1,500 of the feed, rather more than is ever found in milk. The pigs remained in good health and gained steadily in weight. The pigs receiving the formaldehyde gained 94 pounds in the seven weeks of the experiment. As with the pigs fed boric acid, analyses were made of the food and faeces of a couple of the pigs to determine if the formaldehyde had noticeably interfered with the digestion but without positive results. This work was done by A. D. Hall, Principal of the South Eastern Agricultural College, Wye, England. Pigs were selected in preference to other animals as it was stated by the experimenter that they more nearly resembled man in digestive features than any other available animal, and because they were very susceptible to variation in conditions. The last point given in favor of the use of pigs for this work will, to say the least, be regarded as a peculiar claim by most people familiar with this animal. When a pig gets to be a runt, in the common use of that term, it is almost impossible to get it out of this condition and into a healthy growing animal. But, nothing but extremely unfavorable conditions will make a runt of a pig, and the pig is notorious for the kinds and conditions of feed it will eat and still thrive. Decaying food, either grain or flesh, fermenting swill, manure from other stock, are as welcome to the pig as clean food and seem to be healthful. Sour milk produces more rapid gains than sweet. These things would be almost sure death to an infant if continued. Moreover, there are certain things which the pigs can eat which would be poisonous to even an adult person. Ptomain poisoning of pigs seems to be extremely rare, though they eat all kinds of decayed matter. Pigs can eat arsenic with impunity and the bite of the rattlesnake has no effect on them.

E. A. de Schweinitz, Chief of the Biochemical Laboratory, Bureau of Animal Industry of the Department of Agriculture, in reply to an inquiry made by us said that it was true that a pig had a digestive tract more nearly like man than any other animal. He did not believe that tests of preservatives with any but young pigs would be comparable to the effects on the human subject. He thought that any but young pigs were not susceptible to changes in food. He specified that four weeks of age was the limit at which pigs could be compared with the human subject. The pigs used in the experiments mentioned weighed from thirty to forty pounds.

As it requires about a ten weeks old pig to weigh that amount these pigs had gotten beyond the age when they could be considered as particularly valuable for such tests.

What is likely one of the most interesting experiments with preservatives though it had one serious element of weakness in it, was conducted by Dr. H. E. Annette, (Lancet 1899), a Professor in University College, Liverpool, England. Dr. Annette used young kittens about three weeks of age for his experiments. This was about the earliest age at which he considered kittens could live and grow on cow's milk alone. In the first experiment three lots of five kittens in each lot, a total of fifteen kittens were used. According to Dr. Annette's statement the lots were made as equal as possible in age and size. To one lot milk with boric acid, eighty grains to the gallon, was fed. To another lot milk with boric acid, forty grains to the gallon, was fed; while the third lot received milk without boric acid. The kittens were given all the milk they would consume but no record of the amount consumed by each lot was kept. This was a serious mistake and led to the questioning by a number of scientists of the value of the results obtained. Each kitten was weighed at the beginning of the experiment and was weighed each succeeding week, the feeding being continued for four weeks. The weight was given in grams. The following table gives the total weight of each lot of kittens at the beginning and at the end of the experiment;

TABLE VI.

Lot.	Weight at beginning grams.	Weight end 1st week grams	Weight end 2d week grams	Weight end 3rd week grams	Weight end 4th week grams
Lot 1, 80 grains boric acid to gallon milk...	2163	2101	2023	1834	All dead
Lot 2, 40 grains boric acid to gallon milk....	2090	1927	1791		All dead
Lot 3, no preservative	1873	2079	2414	2449	None dead

It can be seen from the foregoing table that there was a steady decrease in the weight of the two lots of kittens receiving boric acid, this decrease being more pronounced the longer the kittens received the preservative. At the end of the fourth week all five of the kittens in the lot receiving eighty grains of boric acid to the gallon of milk were dead, all having died during the fourth week of the feeding. At the end of the third week two of the kittens receiving forty grains of boric acid to the gallon of milk were dead and the other three died during the fourth week. In comparison with this the lot receiving no preservative made rapid gains during the entire period and none of the five kittens in the lot failed to make satisfactory gains. All of the kittens in this lot were alive at the end of the third week. During the fourth week one of them got out of the cage in which it was confined and could not be found, but it was in perfect health at the time and would doubtless have lived during the following week as did the other four in the lot. Considering the fact that there was some question as to the ability of kittens of the age used by Dr. Annette to live on cow's milk it is well to note that as far as weight was concerned the kittens receiving no preservative were the lightest of the three lots and probably would have a harder time living in being removed from their mothers. Dr. Annette said that after the first day there was a noticeable loss of appetite on both lots of kittens receiving the boric acid. This was followed by diarrhoea and general depression. The kittens became greatly emaciated and died.

Dr. Annette followed up these experiments by some similar ones using formaldehyde instead of boric acid. Kittens of the same age were selected, and in dividing them into lots they were selected as far as possible to make all lots equal in weight and size. To one lot of five kittens he gave formaldehyde in milk in the proportion of 1 to 50,000. To compare with this he had a control lot of four kittens receiving no preservative. To another lot of four kittens he gave formaldehyde in milk in the proportion of 1 to 25,000. In comparison with this lot he had a second lot of three kittens to which was fed milk with no preservatives. To another lot of five kittens he gave formaldehyde in milk in the proportion of 1 to 12,500 and in comparison a third lot of three kittens which received milk but no preservative. This experiment is notably fair from the number of control lots receiving no preservative. All lots received all the milk they would drink, but no record was kept of the amounts drank by each lot. Each kitten was weighed at the beginning and at the end of each week, the feeding being continued for six weeks with one lot and control and five weeks with the other lots.

The following table shows the average weekly gain or loss in grams for each during the time the feeding was continued:

TABLE VII.

Kittens receiving 1 to 50,000 Formaldehyde.		Control Kittens.	
1st week average 5 kittens	— 8.2	Average of 4 kittens............	+14.7
2nd week average 5 kittens	+ 3.6	Average of 4 kittens.....	—10.0
3rd week average 5 kittens	+ 28.4	Average of 4 kittens............	+89.2
4th week average 4 kittens	+ 8.2	Average of 4 kittens............	+96.7
5th week average 2 kittens	+145.2	Average of 4 kittens............	+60.5
Total increase, 5 weeks	177.2		251.1

Kittens receiving 1 to 25,000 Formaldehyde.		Control Kittens.	
1st week average 4 kittens	+ 38.0	Average of 3 kittens............	+ 77.6
2nd week average 4 kittens	+114.2	Average of 3 kittens............	+129.6
3rd week average 4 kittens	+ 0.5	Average of 3 kittens............	+ 61.3
4th week average 4 kittens	+ 30.5	Average of 3 kittens............	+104.6
5th week average 4 kittens	+ 7.2	Average of 3 kittens............	— 38.0
6th week average 4 kittens	+ 7.2	Average of 3 kittens............	+ 0.6
Total increase, 6 weeks	196.6		325.7

Kittens receiving 1 to 12,500 Formaldehyde.		Control Kittens.	
1st week average 5 kittens	+20.4	Average of 3 kittens............	+46.6
2nd week average 5 kittens	+25.4	Average of 3 kittens............	+68.3
3rd week average 5 kittens	—18.0	Average of 3 kittens............	+80.6
4th week average 3 kittens	+13.3	Average of 3 kittens	+83.0
5th week average 3 kittens	+55.3	Average of 3 kittens............	+34.0
Total increase, 5 weeks	96.4		312.5

The foregoing table shows some interesting facts. Of the kittens receiving 1 to 50,000 formaldehyde one died during the fourth week and two more died during the following week, while one of the remaining two died shortly afterwards. None of the control kittens fed in comparison with this lot died and the total average gain was much more with the control kittens than with the lot receiving the formaldehyde.

Of the kittens reciving 1 to 25,000 of formaldehyde none died and none died in the control lot fed in comparison. The total average gain was decidedly in favor of the kittens receiving no preservatives as in the former case.

Of the five kittens receiving 1 to 12,500 of formaldehyde two died during the fourth week and none of the control kittens died, while the control kittens made an average total gain of more than three times the gain made by the kittens receiving formaldehyde, six, or nearly half, died.

Dr. Annette was called before the British Commission to give testimony on this work. This, together with the fact that he had published a detailed account in the "Lancet" brought the work before the attention of scientists and aroused quite a storm of criticism which will be considered in detail. The work was particularly criticised because no record was kept of the amount of milk consumed by kittens, and there was, therefore, no way to determine even approximately the amount of preservative consumed by each kitten. Some experimenters believe that the amount of preservative consumed in proportion to the body weight should be considered. Dr. S. Rideal, a well known English scientist, in commenting before the Commission on the work of Dr. Annette said that he believed the kittens were too young as he had tried to raise kittens of the same age on cow's milk and had failed in succeeding to get them to live. This, in the light of all the facts of Dr. Annette's experiments appears to be a very weak argument against the value of the work. Out of a total of ten kittens fed boric acid, everyone died while five of the same age and size fed exactly the same except that they received no boric acid, and supposedly kept under exactly the same conditions not only all lived but gained in weight steadily. It would puzzle one to understand how in one case all the kittens would die and in the other all would live and thrive, unless the boric acid fed had a great influence in bringing about these comparative results. It would seem that the only question there could be of this particular experiment would be in regard to the honesty of Dr. Annette as an experimental worker in striving as far as possible to have all the conditions aside from the preservative the same for all lots of kittens. Nobody questioned his honesty and certainly a Professor in an institution of the character of the one with which Dr. Annette is connected should have been able to see that such simple conditions were the same. It appears very much as though in making this criticism, Rideal simply acknowledged that he was not as good a hand at getting young kittens to live and grow as Dr. Annette.

Dr. Oscar Liebreich (Lancet, Jan. 6, 1900) thought that the kittens got more boric acid according to their weight than would a child of ten months, each receiving all the milk it would drink. He knows, approximately, the amount of milk that the child would drink and assumes that a kitten would drink much more compared to its weight than the child. He thought that Dr. Annette had not proven that boric acid 1 to 2,000 would be dangerous to an infant.

Dr. Thomas Bond in testifying before the British Commission gave as his opinion that Dr. Annette's experiments were of no value as he thought the kittens were receiving much more preservative in comparison to their size than would an infant raised on cow's milk. He said that an infant would consume one and one-half pints of milk per day and the kitten, which was one-seventh as large drank one-third as much milk or one-half-pint. There seems to be no definite knowledge as to how much milk a kitten of five weeks of age will drink. It seems to be the general opinion that about one-half pint would be approximately the quantity.

To determine this point a little more definitely, we took two kittens three weeks of age away from their mother and fed them on cow's milk without preservative. The milk was measured and was kept constantly before them to approximate the experiments of Annette as nearly as possible. The feeding was continued two weeks. The first week the kittens drank about 50 cubic centimeters each per day. The second week they average 80 cubic centimeters each per day. As there is nearly 500 cubic centimeters in a pint it can be seen that the kittens drank only about one-fourth as much as was assumed by those commenting on Annette's work. As these kittens weighed 400 grams each, they drank very little more compared to body weight than would an infant. These kittens gained weight constantly while being fed cow's milk and appeared to remain in perfect health.

It is likely that with the exception of the experiments with children as subjects, the work done by Dr. Annette was the most valuable ever carried out to test the effect of preservatives. There can be no reasonable doubt that in the tests with boric acid this preservative was directly responsible for the death of the kittens fed. These experiments are the only ones recorded in which very young animals were used, and it is more than likely that the results obtained in this case are more comparable with the results that would be obtained in feeding preserved milk to a very young infant than are the results obtained by the experiments in feeding children from two to five years of age with preservatives. Cats, as a rule, are considered to be very hardy animals, though it is easy to understand that very young kittens might be delicate. But whether they are any more delicate than a young infant is questionable, if not a preposterous assumption.

The results of Annette's experiments with formaldehyde are not so positive, but here again we are brought to face with the fact that nearly half of the kittens receiving the preservative died and none of those receiving the untreated milk died. And it is also a fact that the kittens receiving untreated milk made much more rapid gains in weight than the others. In any other line of experiments such positive results when so many animals were used would be considered by experimental workers as being exhaustive and definite, and why these experiments should be discredited is hard to explain.

In giving the Commission the results of his experiments, Dr. Annette said that he expected to continue this work with kittens. A letter addressed to him by this Station in regard to further work brought out the reply that the Government had sent him to Africa on an important mission and he had not had time to carry out his intentions in regard to preservatives.

At the time Dr. Rideal criticised the work of Dr. Annette before the Commission he gave the result of his own work with kittens. He had fed one-half grain per day of boric acid to kittens older than five weeks of age, and found that they grew as fast with the preservative as without. He calculated that at the same rate in proportion to size a child weighing twelve pounds would consume six grains per day of the preservative. It is just as well to understand in this connection that where preservatives are used at all it is entirely possible for a child to receive from twenty to thirty grains per day. Dr. Annette said that he believed the kittens used by Rideal were too old to be compared with infants, and he made this same criticism of practically all the work in feeding preservatives that had been done. It would seem that Annette was more justified in offering criticism than were those who considered that kittens used by him were too young.

A most interesting experiment with formaldehyde was carried out by A. G. R. Foulerton, (Lancet, 1899, p 1427). He found that the ordinary gold fish used in small aquariums for ornamental purposes could live in water containing formaldehyde in the proportion of 1 to 40,000 and as far as could be noticed this preservative had no effect, whatever, on the fish. He concluded from this that the same proportion of formaldehyde could have no effect on the tissues of the stomach of a human being. Foulerton also found that a frog was not affected by being immersed in water containing formaldehyde in the proportion of 1 to 10,000.

It is hard to estimate the value of this work with fish and frogs, as we have no way of knowing what allowances should be made in comparing this work with the probable effect on the tissues of the human subject. One would naturally suppose that if 1 to 40,000 of formaldehyde would have any effect, whatever, on living tissue it certainly would have some effect on the gold-fish that were forced to live continually in it. But on the other hand we know that formaldehyde in that proportion has a noticeable effect on the living tissue of the germs whose growth it retards when added to milk, and the test with the germs is therefore the most delicate. It must be understood that there are a few kinds of fish that can live under the most adverse conditions and in reply to a communication on the subject, the U. S. Fish Commission said that gold-fish is one of the extremely hardy species.

This same questioning might be directed to nearly all the physiological and digestive work done with preservatives. So much of it was with animals which it is idle to compare in constitutional delicacy with a newborn infant or with an invalid whose hold on life is already most uncertain. This criticism applies particularly with the work of Liebreich and also that of Chittenden with dogs, as they are one of the hardiest of animals. And yet Liebreich tried to reason out, and gave as his unqualified opinion, that judging from his work there could be no possible harm to any class of people in drinking milk containing borax or boric acid. He considered his work that was exhaustive and could not be gainsaid.

EXPERIMENTS WITH CHILDREN.

By far the most interesting experiments to determine the effect of boric acid on digestion was carried through by H. D. Hall and H. S. Hammond of the South Eastern Agricultural College at Wye, England, at the suggestion of the British commission appointed to investigate the use of preservatives.

In these experiments three children were used, two boys, one five and the other two and one-half years of age, both being healthy children; and one girl four years of age, who was very delicate, poorly nourished and developed.

The first child fed, a boy two and one-half years of age, and designated as child "A" in the tables, consumed daily 200 grams of bread, 550 cc of milk, 20 grams butter, 30 grams sugar, 50 cc water, 5 grams taffy. The experiment continued over 28 days, food without preservatives being fed the first and last seven days of the experiment. From the seventh to the fourteenth day formaldehyde at the rate of 1 to 18,000 of the total weight of the food was mixed with the milk and during the following seven days formaldehyde was used at the rate of 1 to 9,000 of the total weight of the food. The other children were fed about the same. The following table will show the amounts of fat and protein ingested and excreted in the faeces;

TABLE VIII.

First trial, Healthy Boy two and one half years of age.

	Nitrogen of food	Nitrogen of fæces	Fat of food	Fat of faeces
1st seven days, no preservative...............	48.20	4.14	303.95	18.27
2nd seven days, 1 to 18,000 formaldehyde	46.62	4.49	277.12	19.52
3rd seven days, 1 to 9,000 formaldehyde	44.62	3.54	272.33	15.51
4th seven days, no preservative.............	49.69	3.78	366.05	17.52

Second trial, Healthy Boy five years old

1st seven days, no preservative	53.76	4.36	307.89	18.36
2nd seven days, 1 to 18,000 formaldehyde	57.61	4.32	299.16	19.06
3rd seven days, 1 to 9,000 formaldehyde	55.66	3.82	294.65	18.74
4th seven days, no preservative.............	61.64	4.61	306.49	16.99

3rd. Trial, Weakly Girl Four Years of Age.

1st seven days, no preservative...............	46.56	3.78	272.68	12.44
2nd seven days, 1 to 9,000 formaldehyde	49.11	5.42	263.13	21.71
3rd seven days, no preservative..............	48.95	4.80	294.44	13.65

It was stated that as far as could be observed there was no physical effect of the preservative noticeable. It appears very much in the first two trials that the formaldehyde had stimulated the digestion of the foods given. The larger the proportion of the preservative used the more this is noticed. But in the case of the sickly child the preservative seems to have had just the opposite effect and would show that where the person using the preserved food is weakened by disease the stomach is injured by its presence.

Boric acid and borax were then fed and the time was divided into periods as before. The periods varying, however, in length.

TABLE IX.

1st Trial, Healthy Boy Two and One-Half Years of Age.

Period.	Nitrogen in food grams	Nitrogen in fæces grams	Fat in food grams	Fat in fæces grams	Per cent nitrogen digested	Per cent fat digested
1st period, 8 days no preservative.	55.98	5.16	284.21	19.38	91.	93.
2nd period, 7 days boric acid 1 to 1,800 to 1 to 900.	44.01	4.34	260.13	18.56	90.	92.9
3rd period, 5 days boràx 1 to 600.	30.99	2.95	195.00	9.45	90.5	95.2
4th period, 5 days no preservative.	31.49	3.62	208.40	10.73	88.9	94.9
2nd Trial, Healthy Boy Five Years Old.						
1st period, 5 days, no preservative.	43.20	5.05	188.95	12.83	88.4	93.8
2nd period, 7 days boric acid 1 to 2,000 to 1 to 1000...........	54.42	4.85	283.80	18.26	91.1	93.7
3rd period, 5 days borax 1 to 660.	38.75	4.76	204 30	12.96	87.7	93.7
4th period, no preservative..	39.27	4.58	216 53	9.79	88.4	95.5
3rd Trial, Sickly Girl Four Years Old.						
1st period, 5 days no preservative..........	34.37	3.63	177.50	11.78	89.5	93.4
2nd period, 7 days, boric acid 1 to 1,800 to 1 to 900.	44.01	4.56	260.03	17.12	89.7	93.4
3rd period, 5 days borax 1 to 600.......	31.12	3.75	195.00	12.44	88.0	93.7
4th period, 5 days no preservative.	31.69	3.62	208.40	9.00	88.6	95.7

This table certainly does not show that either the borax or boric acid has any effect on the digestibility of the food eaten. The men who conducted this work thought that none of the preservatives had any effect on the general health of the children used in the experiment. It is very doubtful if the results obtained by these could be compared without reservation to very young infants. The fact that they were able to eat a variety of solid food shows that they were in a manner different from the infant that requires milk.

EXPERIMENTS WITH CALVES AT THIS STATION.

We undertook our work at this Station believing that not sufficient experiments had been carried on along the purely digestive lines to be exhaustive. At the time this work was planned the more interesting experiments with children carried out in England and also that with pigs had not been done. But even considering that particular work, there seemed to us to have been some necessity for the conducting of further similar experiments with some other animals than had as yet been used for this purpose. The purely digestive work had been limited up to that time to the work of Liebreich with dogs, and Chittenden who used the same animal. There can be little question of the unsuitableness of this animal for this purpose as the results are to be compared with the probable effect of the preservatives on one of the most delicate of animals, namely, young infants. The feeding of children who had become accustomed to and were old enough to require solid food rather than milk still leaves room for experiments with younger animals.

For our work, we selected calves as being more suitable than anyone of a number of available animals. Many workers will criticise this choice because the calf has a digestive apparatus entirely different from that of the human or any of our domestic animals. There is however, another side to this question which we considered as being equal in importance to the character of the digestive tract. The calves could be fed preservatives very young as a calf can be removed from its mother as soon as it is born and raised by hand very easily. Moreover, the young calf is not what would be termed a hardy animal as they are especially susceptible to anything wrong with the food given them. It takes a very little irregularity in the feed to disturb the digestion and start the calf to scouring. As cow's milk is the natural food of the calf and cow's milk was to be used as the food in the experiments, we thought that the calf would, considering everything, be as likely to show any effect from preserved milk as any other animal.

In our work with calves we commenced the experiments when the animal was about two weeks of age. As it was necessary or desirable to keep the calf in a standing position during the time that the faeces were to be collected and a calf two weeks of age could not stand up for any length of time a crate was used. A bran sack was fitted with holes through which the calf's legs could be placed and the ends of the sack were swung to nails in the side of the crate. This made it possible for the calf to settle into the improvised sling and still be in position to collect the faeces. A rubber sack was tied under the tail in such a manner as to catch the faeces. The apparatus was designed by us in some previous digestive work with calves. An illustration that gives a fair idea of how it appears when in use is shown in Bulletin No. 77 of this Station. The work was carried on by us at two different times, having commenced on it in the winter of 1900-1901. It was taken up again the winter of

1901-1902 and completed. During the first year we experimented with boric acid, salicylic acid, and formaldehyde, and during the last season we added borax, making four in all. As has been mentioned, salicylic acid is not extensively employed as a preservative of milk, but it is used in other food products and we considered this a good time to determine its effects as far as possible. The first year these experiments were conducted the various preservatives were added to the milk just a few minutes before it was fed to the calves. But there is a possibility that the prolonged action of the preservative might have some influence on the digestibility of the milk, and in practice preservatives are of course added to the milk some time before it is consumed. So in our recent work the preservative was added to the milk twenty-four hours before it was fed, and it was allowed to stand in a comparatively warm room.

In our digestion work we used boric acid in the proportion of 1 to 1,000 borax 1 to 675, salicylic acid 1 to 1,000 and formaldehyde 1 to 10,000. All of these proportions are in excess of the quantities usually supposed to be sufficient in dairy practice. But we thought that with the borax and boric acid it would require this proportion to add materially to the keeping qualities of the milk. The formaldehyde was in greater proportion than is required but it was our intention if this large proportion had any bad effect to diminish the proportion of formaldehyde added to what would actually be required to keep the milk for a sufficient length of time for practical work. As events turned out we found it unnecessary to try the smaller quantity.

The general plan of the work was to feed the calf a preliminary period of three days which we considered a sufficient length of time for all food to pass through the digestive tract, as nothing but milk was given the calf. Then the faeces were collected for three days, the calf in the meanwhile being confined in the crate. A longer period for collecting the faeces would undoubtedly have been better, but it is likely that three days was about the limit of time a young calf could be confined in an upright position without becoming so fatigued as to influence the results. The faeces were collected every day, weighed and sampled, the size of the sample being in proportion to the amount excreted. These samples were air-dryed and added together for analysis for fat and protein.

The milk fed the calves was for the first year of our work taken from the same two cows throughout the entire period. We thought this would be better than taking from the entire herd as milk from different cows is supposed to differ in digestibility and by taking from a few cows would obviate this possible error. The last year of our work another cow was added, making three from which the milk was fed constantly.

It will be noticed from the tables that in the last year's work an effort was made to make the test of each preservative as fair as possible by commencing different calves with a different preservative. As each calf was fed in turn on all of the preservatives used, and six days was required for each, it can be seen that the calf was considerably older at the end of the series than at the beginning. It was entirely possible that a difference of a few weeks in age might make a material difference in the effect of the preservatives on the animal.

No faeces were collected from calves that commenced to scour after the beginning of the feeding. In such case the feeding was stopped until the calf regained its natural condition or was continued until a sufficient time after the scouring ceased to insure that it would have no effect on the result of the test. In cases where calves were not satisfactory through refusing occasionally to drink the full amount of milk they were discarded and other calves were substituted.

About the quantity of milk required to keep the calf in growing condition was fed, the amount always being the same for all calves.

Tables X and XI show the composition of the milk fed and the faeces collected in the different tests. These can be identified with the tables showing the per cents digested in the different trials by the index numbers which are the same in both cases. The babcock test was used for fat determinations of milk.

TABLE X.

Composition of Milk Used in the Following Experiments.

No. Index		Water per cent	Protein per cent.	Fat per cent
2581	Whole milk preserved with Boric acid.......	87.00	3.36	3.80
2589	“ “ “ “ “ “	87.00	3.20	4.00
2597	“ “ “ “ nothing..........	86.50	3.70	4.40
2604	“ “ “ “ salicylic acid...	86.50	3.32	4.20
2611	“ “ “ “ formaldehyde..	86.50	3.36	4.10
2627	“ “ “ “ “	86.50	3.55	4.60
2633	“ “ “ “ salicylic acid...	86.50	3.32	3.80
2539	“ “ “ “ nothing..........	86.50	3.52	4.40
2645	“ “ “ “ boric acid.......	86.50	3.41	4.10
2661	“ “ “ “ formaldehyde..	86.50	3.55	4.60
2664	“ “ “ “ “	86.50	3.55	4.60
2668	“ “ “ “ nothing..........	86.50	3.64	3.60
2673	“ “ “ “ borax...............	86.50	3.18	3.80
2679	“ “ “ “ “	86.50	3.22	4.00
2683	“ “ “ “ nothing..........	86.50	3.64	4.60
2685	“ “ “ “ salicylic acid...	86.50	3.18	3.80
2701	“ “ “ “ nothing..	86.50	3.70	4.50
2709	“ “ “ “ boric acid..	86.50	3.40	4.60

TABLE XI.

Composition of Fæces in Digestive Experiments.

No. Index	Description of Sample.	Water per cent	Protein per cent.	Fat per cent
2589	Calf 1, Fed whole milk, Boric acid	81.82	8.59	2.32
2592	“ 2, “ “ “ “ “	83.26	8.72	3.40
2600	“ 2, “ “ “ no preservative.....	63.72	6.45	4.94
2607	“ 2, “ “ “ salicylic acid........	73.64	7.26	8.80
2614	“ 2, “ “ “ formaldehyde.	88.98	5.95	2.00
2630	“ 3, “ “ “ “	79.59	11.69	4.43
2636	“ 4, “ “ “ salicylic acid........	73.71	12.10	6.61
2642	“ 4, “ “ “ no preservative.....	83.43	7.96	2.47
2648	“ 4, “ “ “ boric acid.............	75.49	6.97	2.25
2663	“ 5, “ “ “ formaldehyde. . ..	72.37	10.87	5.24
2666	“ 4, “ “ “ “	80.72	5.33	1.96
2671	“ 5, “ “ “ no preservative.....	79.42	8.99	4.55
2676	“ 4, “ “ “ borax.	85.29	5.56	1.40
2682	“ 5; “ “ “ “	70.65	10.37	5.97
2686	“ 4, “ “ “ no preservative. ..	81.21	4.71	2.14
2689	“ 5, “ “ “ salicylic acid	84.96	6.60	5.10
2704	“ 5, “ “ “ no preservative.. ...	84.88	4.39	1.61
2712	“ 5. “ “ “ boric acid...	80.15	4.88	1.15

As the work of the two different years varied in having the preservative added to the milk at different times we have given the results with each preservative for the two years in separate tables. The average digestibility of untreated milk given in Tables XII, XIII, XIV, in comparison with the preserved milk was taken from a table from some previous digestion work done the same year and partially with the same calves. The details of this may be found in Bulletin No. 77 of this Station.

The calves fed were numbered, thus calf 8 was used in the trials of all the preservatives. But it must be noted that while the numbers in the tables showing the work of the first year correspond, they do not correspond with the numbers of the calves used in the work of the second year and are given in the tables showing the result of the work done at that time, as of course a new lot of calves were used and we commenced the numbering at 1, as we had in the work of the previous year.

The following Table gives the results of the trials with salicylic acid;

TABLE XII.

Digestibility of Whole Milk Preserved with Salicylic Acid.

(Preservative Added Just Before Feeding.)

Duration of Preliminary Period, three days.
Duration of Digestion Period, three days.

Index No		Fresh substance gram	Dry substance grams	Moisture per cent	Protein grams	Fat grams
	Calf 4, Age 52 days					
2494	Milk fed	18,714	2,536	86.50	636.27	785.98
2502	Total excreted	1,825	526	71.18	111.69	65.59
	Digested				524.58	720.39
	Per cent digested				82.44	91.12
	Calf 8, age 14 days.					
2526	Milk fed	18,714	2,536	86.50	619.43	767.27
2529	Total excreted	557	168	70.78	39.56	24.55
	Digested				579.87	742.72
	Per cent digested				93.61	96.80
	Average for two tests with salicylic acid				88.02	93.96
	Average for raw milk				94.79	96.82
	Decreased digestibility caused by salicylic acid				6.77	2.86

The first trial was made with calf 4 which was nine weeks old at the time. The calf was in perfect health at the commencement of the preliminary period and apparently remained so throughout the six days he was fed with acid. The faeces collected were very light colored and were dry and hard. On the second day the calf was in the crate there was a thick slime with almost the consistency of a membrane which came with the faeces. It will be noted that there was a very large amount of faeces during the three days. The table shows that 82.44 per cent of the protein and 91.12 per cent of the fat in the milk taken was digested. A relatively small per cent.

The second trial was carried through with calf 8 which was fourteen days old at the commencement. He was in good health at the time he was placed in the crate but became so restless that we could not collect the faeces the second day which necessitated us keeping him in the crate four days. The day after he was removed from the crate he commenced to scour badly. This may have been caused by the salicylic acid. The hat in the second trial recorded, 93.61 per cent of the protein and 96.80 per cent of the fat was digested. The average of the two trials of the protein was 88.02 per cent and for the fat 93.96 per cent digested. Comparing this with the raw milk digested, we find 6.77 per cent of protein and 2.86 per cent of fat in favor of the milk without the preservative.

Previous to the work with calf 8 we had made two trials with another calf which resulted in his scouring both times before the faeces had been collected. In the first trial he was but two weeks old, was in perfect health at the beginning of the trial but at the end of the third day of the preliminary period was scouring badly, the faeces being very white and milky looking. As soon as the acid was discontinued the scouring ceased. The second trial was made when the calf was four weeks old. Everything was satisfactory in the preliminay period but when he was confined in the crate he commenced to pass large quantities of blood with the faeces which were rather thin though the calf was not scouring. This blood continued to pass and we did not collect the faeces. Even after the calf had recovered from the tendency to scour the faeces were still very bloody.

The trials of the boric acid were then taken up and the results will be seen in the following table:

TABLE XIII.

Digestibility of Whole Milk Preserved with Boric Acid.
(Preservative Added Just Before Feeding.)

Duration of Preliminary Period, three days.
Duration of Digestion Period three days.

Index No.		Fresh substance grams	Dry substance grams	Moisture per cent	Protien grams	Fat grams
	Calf 7, age 28 days					
2535	Milk feed....................	18,714	2,432	87.00	626.91	711.13
2511	Total excreted..............	860	221	74.12	43.94	22.01
	Digested....................				582.97	698.12
	Per cent digested.........				92.99	96.90
	Calf 8, age 27 days					
2533	Milk fed.....................	12,576	1,697	86.50	402.43	528.19
2539	Total excreted.............	735	86	88.27	21.38	13.66
	Digested.....................				381.05	544.53
	Per cent digested.........				94.68	97.43
	Average for two trials preserved with Boric acid.........				93.84	97.16
	Average of raw milk..				94.79	96.82
	Decrease caused by Boric acid..................................				.95	.34

The first trial was carried through with calf 7 which was four weeks old. The first day he was in the crate he scoured slightly though the faeces were collected, and the second and third days the faeces were very hard and dry. The table shows that 92.99 per cent of the protein and 96.90 per cent of the fat in the milk consumed was digested.

The second trial was made with calf 8 which was twenty-seven days of age. He was in perfect condition at the beginning of the preliminay period but his bowels were a little loose the first day he was confined in the crate. The second day his bowels were still loose and the third day he was scouring so badly that we decided not to collect the faeces, allowing the two first days to stand as a basis on which to calculate results. The table shows that he digested 94.68 per cent of the protein and 97.43 per cent of the milk consumed. The average for the two trials shows 93.84 per cent of the protein and 97.66 per cent of the fat digested. Comparing this with the digestibility of the untreated milk we find that .95 per cent more protein in the milk without the preservative was digested and .34 per cent more fat in the milk treated with boric acid was digested. Previous to the last successful trial with boric acid we had made three trials which did not terminate satisfactorily, the calves scouring in each case before they were confined in the crate. In one case the scouring commenced the second day of the preliminary period and the faeces were very frothy. The other calf commenced to scour the second day of the preliminary period and the acid was discontinued. Another trial with the same calf after he had recovered from the first trial resulted in scouring the evening of the third day of the preliminary period.

Formaldehyde was the third and last preservative tried, 1 to 10,000 parts of milk being used. The following table gives the results of the two trials:

TABLE XIV.

Digestibility of Whole Milk Preserved with Formaldehyde.

(Preservative Added Just Before Feeding.)

Duration of Preliminary Period, three days.
Duration of Digestion Period, three days.

Index No.		Fresh substance grams	Dry substance grams	Moisture per cent	Protein grams	Fat grams
	Calf 9, age 35 days.					
2540	Milk fed....................	18,714	2,432	87.00	632.53	711.13
2534	Total excreted..............	535	151	70.56	32.56	14.60
	Digested.....................				599.97	696.53
	Per cent Digested.........				94.85	97.94
	Calf 8, Age 38 days.					
2547	Milk fed....................	18,714	2,536	86.50	640.01	767.27
2551	Total excreted.........	750	131	82.54	30.80	18.82
	Digested.....................				609.11	748.45
	Per cent digested..........				95.17	97.56
	Average 2 tests of milk preserved with formaldehyde.				95.01	97.75
	Average whole milk untreated..................................				94.79	96.82
	Difference in favor of milk preserved with formaldehyde..				.22	.95

The first trial was made with calf 9 which was five weeks of age. He was in normal condition at the commencement but when placed in the crate the manure was hard and dry. The table shows that 94.85 per cent of the protein and 95.17 per cent of the fat consumed was digested.

The second trial was made with calf 8 which was thirty-eight days of age. Everything during this period was normal. The table shows that 95.17 per cent of the protein and 97.56 per cent of the fat consumed was digested. The average for the two trials was 95.56 per cent of the protein and 97.75 per cent of the fat. Comparing this with the digestibility of the untreated milk we find .22 per cent of the protein and .93 per cent of fat in favor of the milk with the formaldehyde.

We now take up the work done by us during the second season of our experiments with preservatives. It will be remembered that these vary somewhat from the others in having the preservative added to the milk twenty-four hours before it was fed to the calves. It will also be noted from the tables that the calves ran on the average, a little younger than in the previous season's work. The following tables show the result of the trials with the different preservatives:

TABLE XV.

Digestibility of Whole Milk, Boric Acid 1 to 1,000.
(Preservatives added twenty.four hours before feeding)

Duration of Preliminary Period, three days.
Duration of Digestion Period, three days.

Index No.		Fresh substance grams	Dry substance grams	Per cent moisture	Protein grams	Fat grams
	Calf No. 1, age 14 days					
2581	Milk fed..........	19,500	2,535	87.00	655.20	741.00
2584	Total excreted..............	665	121	81.82	57.15	15.48
	Digested..				598.05	725.52
	Per cent digested..........				91.27	27.91
	Calf No. 2, age 14 days					
2589	Milk fed........................	19,500	2,535	87.00	624.00	780.30
2592	Total excreted.............	670	123	83.26	58.42	22.84
	Digested				565.58	757.16
	Per cent digested..........				90.62	97.07
	Calf No 4, age 37 days.					
2645	Milk fed........................	19,500	2,643	86.50	665.95	799.50
2648	Total excreted..............	865	213	75.49	60.38	19.49
	Digested.........				604.57	780.01
	Per cent digested..........				90.09	97.56
	Calf No. 5, age 50 days.					
2709	Milk fed........................	19,500	2,643	86.50	653.00	897.00
2712	Total excreted..............	1,080	215	80.15	52.74	12.44
	Digested.........				610.26	610.26
	Per cent digested..........				93.03	98.60
	Average of milk preserved with boric acid..................				91.00	97.56
	Average of milk untreated......................................				93.52	97.37
	Decrease in digestibility caused by boric acid............				2.52	.19

TABLE XVI.

Digestibility of Whole Milk preserved with Borax 1 : 675.
(Preservatives added twenty-four hours before feeding)

Duration of preliminary period, three days.

Duration of digestive period, three days.

Index No.		Fresh sub stance grams	Dry sub-stance grams	Per cent moisture	Protein grams	Fat grams
	Calf No. 4, age 49 days.					
2673	Milk fed	19,500	2,643	86.50	620.10	741.00
2676	Total excreted	850	126	85.29	47.28	11.97
	Digested				572.82	729.03
	Per cent digested				92.37	98.28
	Calf No. 5, age 26 days.					
2679	Milk fed	19 500	2,643	86.50	627.90	781.00
2682	Total excreted	480	141	70.65	49.79	28.69
	Digested				578.11	752.31
	Per cent				92.07	96.32
	Average of milk preserved with Borax				92.22	97.35
	Average of untreated milk				93.52	97.37
	Decrease in digestibility caused by borax.				1.30	.02

TABLE XVII.

Digestibility of Whole Milk Preserved with Formaldehyde.

(Preservative added twenty four hours before feeding.)

Duration of preliminary period, three days.
Duration of digestive period, three days.

Index No.		Fresh substance grams	Dry substance grams	Per cent moisture	Protein grams	Fat grams
	Calf No. 2, age 34 days.					
2611	Milk fed	19,500	2,642	86.50	655.10	799.50
2614	Total excrement............	600	187	68.98	35.70	12.52
	Digested.........................				619.50	786.98
	Per cent digested.				94.55	98.43
	Calf No. 3, age 14 days.					
2627	Milk fed	19.500	2,643	86.50	692.25	897.00
2630	Total excrement............	385	79	79.59	45.07	17.06
	Digested..........................				647.18	879.94
	Per cent digested.				93.63	98.09
	Calf No. 5, age 14 days.					
2660	Milk fed..........................	19,000	2,643	86.50	692.25	897.00
2663	Total excrement..	335	93	72.37	36.42	17.58
	Digested.,.......................				655.83	879.42
	Per cent digested..........				94.73	98.04
	Calf No. 4, age 43 days.					
2664	Milk fed..........................	12,500	2,643	86.50	655.20	799.50
2666	Total excrement............	440	83	80.92	23.47	8.66
	Digested..........................				631.73	790.84
	Per cent digested.......... .				96.41	98.91
	Average for milk preserved with formaldehyde.				94.83	89.36
	Average for untreated milk...				93.52	97.37
	Difference in favor of milk treated with formaldehyde				1.31	.99

TABLE XVIII.

Digestibility of Whole Milk preserved with Salicylic Acid.
(Preservatives added twenty-four hours before feeding.)
Duration of Preliminary period three days.
Duration of Digestive period three days,

Index No.		Fresh substance grams	Dry substance grams	Per cent moisture	Protein grams	Fat grams
	Calf No 2, age 28 days.					
2604	Milk fed	19,500	2,643	86.50	649.40	819.00
2607	Total excrement	850	225	73.64	61.74	74.80
	Digested				587.66	744.20
	Per cent digested				90.49	90.86
	Calf No. 4, age 25 days.					
2633	Milk fed	19,500	2,642	86.50	649.40	741.00
2636	Total excrement	500	122	73.70	60.50	46.50
	Digested				610.69	694.50
	Per cent digested				89.14	93.72
	Calf No. 5. age 32 days.					
2686	Milk fed	19,500	2,643	86.50	620.10	741.00
2689	Total excrement	890	134	84.96	58.74	45.39
	Digested				561.36	695.61
	Per cent digested				90.51	93.87
	Average test of milk preserved with salicylic acid				90.04	92.81
	Average untreated milk				93.52	97.37
	Decrease in digestibility caused by salicylic acid				3.48	4.56

TABLE XIX.

Digestibility of Whole Milk Untreated.
Duration of Preliminary Period, three days.
Duration of Digestive Period, three days.

Index No.		Fresh substance grams	Dry substance grams	Moisture Per cent	Protein grams	Fat grams
	Calf No. 2, age 22 days.					
2597	Milk fed	19,500	2,643	86.50	721.50	858.00
2600	Total excrement	685	249	63.72	44.23	33.86
	Digested				677.27	824.14
	Per cent digested				94.56	96.05
	Calf No. 4, age 31 days.					
2639	Milk fed	19,500	2,643	86.50	686.40	858.00
2642	Total excrement	590	98	82.43	47.01	14.60
	Digested				639.40	843.40
	Per cent digested				93.16	98.06
	Calf No. 5, age 20 days.					
2668	Milk fed	19,500	2,643	86.50	709.80	858.00
2671	Total excrement	500	103	79.42	44.08	22.77
	Digested				644.82	825.34
	Per cent digested				93.66	97.34
	Calf No. 4, age 55 days.					
2683	Milk fed	19,500	2,643	86.50	709.80	858.00
2689	Total excrement	1,100	207	81.23	51.86	23.63
	Digested				657.94	834.37
	Per cent digested				92.69	97.24
	Calf No. 5, age 55 days.					
2701	Milk fed	19,500	2,643	86.50	721.50	877.50
2704	Total excrement	990	159	84.88	43.53	16.01
	Digested				677.97	861.49
	Per cent digested				93.52	98.37
	Average whole milk untreated				93.52	97.17

The first trial was made with Calf No. 1 feeding milk preserved with boric acid and everything went through the six days in a perfectly satisfactory manner. The calf, as can be seen in Table XIV, digested 91.27 per cent of the protein and 97.91 per cent of the fat fed in the milk. It gained three pounds in weight during the three days it was confined in the crate. Unfortunately this calf could not be used in any more of our work as it got so it occasionally refused to drink the milk given.

FIRST SERIES.

The next trial was made with Calf No. 2 feeding milk preserved with boric acid as before. It was in normal condition during all the six days the milk was fed. It dropped a very small amount of manure and what it did drop was very muscilagenous in its consistency. The calf acted as though it might have been a little uncomfortable in the crate but it struggled none whatever. Table XV shows that of the protein and fat eaten in the milk, 90.63 per cent of the protein and 97.07 per cent of the fat was digested. The calf gained five pounds.

Calf No. 2 was then fed milk without any preservative. Nothing worthy of note occurred in the six days as everything was apparently normal. Table XIX shows it to have digested 94.56 per cent of the protein and 96.05 per cent of the fat. This is a material increase in the per cent of protein digested over the per cent digested while the calf was receiving boric acid, but was a slight decrease in the per cent of fat digested. Calf No. 2 was then fed milk preserved with salicylic acid. The sack used for keeping it in the crate in previous trials had caused a large sore under one hind leg, evidently through preventing the circulation of blood. So in this trial the rubber sack to catch the faeces was tied on as usual but the calf was allowed the liberty of a stall. This plan worked fairly well as none of the faeces were lost by the calf lying down, though it was a little inclined to scour one of the six days. Otherwise, everything was in normal condition. This was the first and only calf that ever suffered any physical harm during all of our work, but it is doubtful if this was severe enough to influence the results of the trials. Table XVIII shows that 90.49 per cent of the protein and 90.86 per cent of the fat eaten in the milk was digested. This is a decided decrease from the per cents digested when the calf was fed untreated milk. The calf gained three pounds in weight during the time it was in the crate.

Calf No. 2 was next fed milk preserved with formaldehyde. The sore in the leg was still in such condition that we allowed it the liberty of a stall while collecting the faeces. The faeces collected were very hard, dry and dark colored. Table XVII shows that 94.55 per cent of the protein and 98.43 per cent of the fat were digested when untreated milk was fed. The calf gained five pounds in weight.

SECOND SERIES.

The next series was carried through with calf 4; calf 3 having proven unsatisfactory. Calf 4 was first fed milk preserved with salicylic acid. This calf was an unusually large and vigorous animal and was a very hearty feeder. It went through this trial in fine shape. Table XVIII shows it to have digested 89.14 per cent of the protein and 93.72 per cent of the fat in the milk taken. It gained five pounds. In the next trial the calf was fed on milk without the preservative and went through the six days in satisfactory shape. Table XIX shows it to have digested 93.16 per cent of the protein and 98.06 per cent of the fat taken in the milk, considerably more of each than was digested when fed on milk preserved with salicylic acid. The calf gained two pounds in this trial. Calf 4 was then fed on milk preserved with boric acid. Everything was normal but the calf dropped a large quantity of manure. Table XV shows it to have digested 90.09 per cent of the protein and 97.56 per cent of the fat consumed. It lost 4 pounds during the three days. For the next trial it was fed on milk preserved with formaldehyde. Everything went through in normal condition. Table XVII shows it to have digested 96.41 per cent of the protein and 98.91 per cent of the fat. It gained two pounds in weight in the three days of the digestion period. No. 4 was then fed on milk preserved with borax. The faeces were very hard and dry during this trial, but otherwise there was nothing worthy of note. Table XVI shows it to have digested 92.37 per cent of the protein and 98.38 per cent of the fat fed in the milk. Calf 4 was then fed a second time on milk without preservative. There was nothing worthy of note. Table XIX shows it to have digested 92.69 per cent of the protein and 97.24 per cent of the fat in the milk taken. This is less than the per cent digested in the previous trial with milk without preservative. In the two trials with plain milk an average of 92.92 per cent protein and 97.65 per cent of fat was digested. This was very much less than the per cents digested when milk preserved with formaldehyde was fed, but more than was digested when milk with any of the other preservatives was fed.

THIRD SERIES.

The next and last series was carried through with calf 5. It was first fed milk preserved with formaldehyde. It went through the trial in good condition but dropped very little manure which was hard, dry and very dark colored. Table XVII shows this calf to have digested 94.73 per cent of the protein and 98.04 per cent of the fat in the milk consumed. The next trial was made with untreated milk and this calf went through the six days in good condition and as in the previous trial, dropped very little manure. Table XIX shows it to have digested 93.66 per cent of the protein and 97.34 per cent of the fat in the milk. Milk preserved with borax was then fed. There was nothing worthy of note in this period except that the faeces were hard and dry and dark colored. Table XVI shows it to have digested 92.07 per cent of the protein and 96.32 per cent of the fat in the milk consumed. The next trial was with milk preserved with salicylic acid. The second day that the calf was in the crate the faeces were a little soft and of a very offensive odor. This had disappeared the third and last day the faeces were collected. We considered it on the whole a very satisfactory trial. Table XVIII shows that 90.51 percent of the protein and 93.87 per cent of the fat in the milk consumed was digested. The next trial was made with milk preserved with boric acid, but the calf started to scour and continued to scour for three days, the boric acid being continued that time. The acid was discontinued and the calf stopped scouring. Milk without preservatives was then fed and the next trial was made with the calf going through the period without anything worthy of note occuring. Table XIX shows it to have digested 93.76 per cent of the protein and 98.17 per cent of the fat in the milk consumed. The next trial was with boric acid. The faeces were hard and dry. Table XV shows it to have digested 92.03 per cent of the protein and 98.60 per cent of the fat in the milk consumed.

In this third and last series it is shown that with the untreated milk in the two trials an average of 93.70 per cent of the protein and 98.45 per cent of the fat in the milk consumed were digested- This is a smaller per cent of protein than was digested with any of the other preservatives and a larger per cent of fat than was digested in any trial with boric acid.

In Table XVII it will be noticed that one trial was made feeding milk preserved with formaldehyde to calf 3, the same not being used with any of the other preservatives. The calf went through this trial in a satisfactory shape but we desired to use him for some work that will be mentioned further along, so no other trials were made with him.

SUMMARY.

In comparing the total averages for each table we find that 1.31 per cent more protein and .99 per cent more fat was digested when milk was preserved with formaldehyde than when it was fed without preservatives. When the milk was preserved with salicylic acid there was a difference of 3.48 per cent of protein and 4.56 per cent of fat in favor of the untreated milk. When milk was preserved with borax there was a difference of 1.30 per cent of protein and .02 per cent of fat in favor of the untreated milk. When milk treated with boric acid was fed there was a difference of 2.52 per cent of protein in favor of the milk without preservatives and .19 per cent of fat in favor of the preserved milk. In all of the series the comparative results were nearly the same and the results in the two seasons' work were so nearly the same that it would appear that the work was exhaustive and could be depended upon to represent fairly well the results that would be obtained if this same line of work was carried on indefinitely. The results obtained in our work are practically the same as obtained by other workers. Borax and boric acid in the experiments conducted by other men appeared to slightly prevent digestion while formaldehyde had the opposite effect.

From the results of this work many people may be inclined to think that milk preserved with formaldehyde is even to be preferred to milk treated with no preservative,as the tables evidently show it to be more digestible. We are not qualified to enter into any physiological argument on this proposition, but it would be entirely possible for the preservative to render the milk more digestible and still have properties that would prove injurious. It is entirely possible for the preservative to unduly stimulate the digestive organs and in the course of time bring them to a diseased condition. For this reason it is impossible to say that formaldehyde, if injurious, is the least injurious of any of the preservatives used in the milk business. In this connection it might be stated again that the results obtained by Annette in feeding formaldehyde to kittens where almost half of the kittens died would be more likely to represent what would occur in feeding preserved milk to very young infants.

The fact that the other preservatives used made the milk less digestible is sufficient to condemn them. Adults could possible drink such milk with impunity, but in the tenement districts of cities where the babies have a hard struggle for existence it takes a very little to turn the scale either in favor or against their chances for life.

TABLE XX.

Average Digestibility in Different Trials.

Knd of preservatives.	Protein digested per cent	Fat digested per cent
Salicylic acid added just before feeding	98.02	93.96
Boric acid added just before feeding	93.84	97.16
Formaldehyde added just before feeding	95.01	97.75
Boric acid added 24 hours before feeding	91.00	97.57
Borax added 24 hours before feeding	92.22	97.35
Formaldehyde added 24 hours before feeding	94.83	98.36
Salicylic acid added 24 hours before feeding	90.04	92.81
No preservative. Fed to the calves which received milk to which the preservative was added 24 hours before feeding	93.52	97.37

TABLE XXI.

Gains or Losses in Weight During Three Days of Digestive Period

No. Calf.	Index No.	Preservative	Gain lbs.
1, Age 14 days	2584	Boric acid	3
2, Age 14 days	2592	Boric acid	5
2, Age 22 days	2600	No preservative	2
2, Age 28 days	2607	Salicylic acid	3
2, Age 34 days	2614	Formaldebyde	5
3, Age 14 days	2730	Formaldehyde	9
4, Age 25 days	2636	Salicylic acid	4
4, Age 31 days	2642	No preservative	2
4 Age 37 days	2648	Boric acid	—4
5, Age 14 days	2663	Formaldehyde	4
4, Age 43 days	2666	Formalnehyde	2
5, Age 20 days	2671	No preservative	0
4, Age 49 days	2676	Borax	—1
5, Age 26 days	2682	Borax	5
4, Age 55 days	2686	No preservative	0
5, Age 32 days	2689	Salicylic acid	2
5, Age 44 days	2704	No preservative	2
5, Age 50 days	2612	Boric acid	—2
Average gain for boric acid			½
Average gain for salicylic acid			3
Average gain for formaldehyde			5
Average gain for no preservative			1+

EFFECT OF FEEDING PRESERVATIVES THROUGH A LONG PERIOD.

To determine if preservatives would have any effect if given through a comparatively long period, we fed two calves on milk preserved with boric acid and two with milk preserved with formaldehyde, commencing March 4, and continuing the work till April 24. These calves were in perfect condition as far as could be seen at the beginning of these trials and the calves fed formaldehyde continued so throughout the entire time that the feeding was continued. All of the calves gained steadily in weight throughout the experiment. The calves receiving the boric acid lost nearly all the hair from off their necks and shoulders and it appeared very much as though it was due to the preservative. The following table shows the gain in weight of calves receiving the boric acid and formaldehyde. Calves "A" and "B" received formaldehyde and calves "C" and "D" received boric acid.

TABLE XXII.

Weight of Calves.

	Calf A.	Calf B.	Calf C.	Calf D.
March 11	88	109	104	93
March 26	101	124	121	96
April 1	102	125	124	103
April 15	124	140	137	110
April 24	131	151	152	115
Gain in 44 days	43	42	48	22

CONCLUSIONS.

It is very hard to draw any definite conclusions looking to the use of preservatives, either from the work done at this Station or that of other workers. The investigation into the effect of preservatives has given practically the same results in all the trials with mature animals. We find that in the work of Chittenden with dogs and also that of Liebreich with dogs borax and boric acid interfered slightly with the digestion of the food eaten. It is doubtful if this was sufficient by itself to condemn the use of these preservatives except under particular conditions, such as that of illness or infancy. In the trials authorized by the British Commission, neither boric acid nor formaldehyde seemed to have any marked effect on the digestion of the food eaten. In the trials to determine the effect of preservatives on the bodily health, a gain in weight of animals there was a unanimity of results with mature animals which for the conditions would seem to be conclusive. Both Chittenden and Liebreich found that dogs fed borax or boric acid gained steadily in weight and, as far as could be observed, suffered no injury, whatever, from the preservative. Rabbits and guinea pigs fed borax by Liebreich gained in weight and remained in perfect health. The pigs and children fed boric acid and formaldehyde at the instance of the British Commission suffered no evil result from the preservative and the pigs made substantial gains. The calves fed for an extended period with milk preserved with boric acid and formaldehyde made very satisfactory gains in weight. The two receiving the boric acid lost a good share of their hair, presumably from the effects of the acid.

It would certainly be hard to conclude from all of these results that preservatives are harmful and should therefore be prohibited. On the other hand many have concluded that as there seems to be some need for preservatives with some foods, they should be used.

But on the other hand there stands the work of Annette with young kittens which seems to oppose all of these negative results obtained by so many other workers. The results obtained by Annette were quite positive and showed the preservatives to be not only harmful but resulted fatally when fed to kittens; which would seem to indicate that the use of preserved milk for infants incures great risks. Taking all of these facts into consideration, it would seem, that until more definite knowledge to the contrary is obtained that the safest course to pursue would be to discourage the use of preservatives in milk in every way possible.

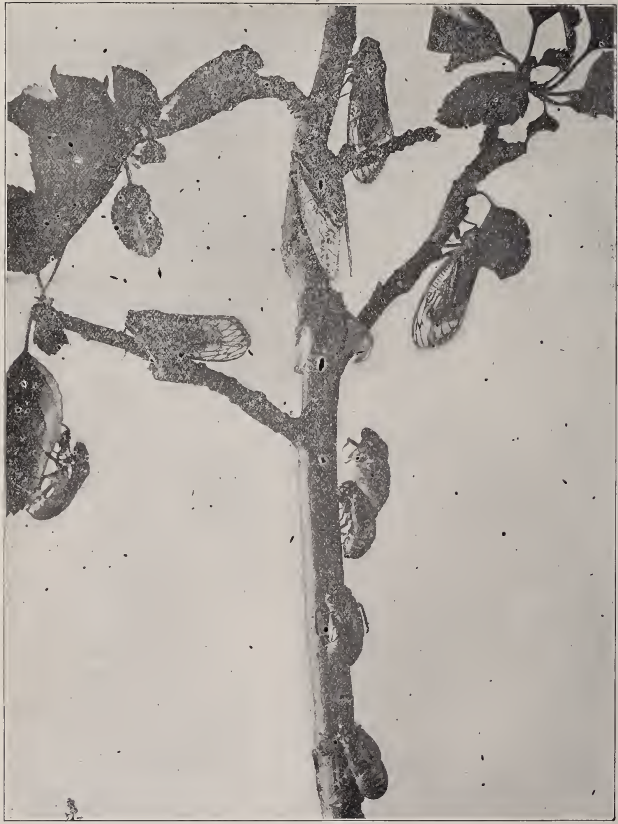

PLATE I.—Illustrating some of the different stages in the course of transformation of the Periodical Cicada.

THE MARYLAND
AGRICULTURAL EXPERIMENT STATION.

Bulletin No. 87. November, 1902.

THE PERIODICAL CICADA, AND ITS OCCURRENCE IN MARYLAND IN 1902.

BY A. L. QUAINTANCE, ENTOMOLOGIST.

The periodical cicada, or so called "seventeen-year locust", stands without parallel among the insects of the world in point of longevity, and is further remarkable from the fact that for practically the seventeen* years of its existence, it lives a subterranean life. With almost exact regularity, the insects appear from the ground in countless millions over an area of many thousands of square miles, shed their pupal skins, and attain maturity almost in the course of a single night. Little wonder then that in times past, its sudden appearance in such hords was the cause of much wonder and alarm among the early settlers, and that many erroneous ideas and superstitions concerning it should have prevailed. Even at the present time a predicted visitation of the insect, often excites serious fears among those unfamiliar with its life history and habits, particularly for the welfare of favorite trees and shrubs. There is, perhaps, in some localities reason for this disquietude, but on the whole the anxiety felt is quite out of proportion to the injury likely to occur.

The periodical cicada becomes notably injurious, only in the course of its egg laying. Soon after emerging, the female begins to puncture the smaller twigs and branches of various shrubs and trees, in which the eggs are deposited, the effect of which is to cause a considerable browning and dying of the parts affected. Decided marks of their visitation therefore soon appear. The final result is a more or less general pruning, which to your fruit trees and shrubs, may be decidedly injurious; yet to forest trees which are the receptacles of by far the greater part of the eggs, the result is not particularly serious, the more evident signs of injury disappearing largely by the close of the season.

Probably the earliest account of the appearance of the periodical cicada is that mentioned by Harris in his "Insects Injurious to Vegetation", second edition, page 180, as occurring in Moreton's "New England Memorial", where it is stated that in the spring of 1633 a swarm appeared in Plymouth. It can be readily surmised as has been suggested by various writers, that the term "locust" became associated with this insect by our early fore-fathers, from similarity of the visitation of this species, to the devastating hords of the migratory locust of the Orient. The insect was described by Linneus in 1758. Owing to its anomalous life history, it was early the subject of investigation by naturalists and others, so that at the present day there is a considerable literature on the species, and its life history and habits are perhaps quite generally known. Of the more recent and valuable writings, should be mentioned those of Harris, in his "Insects Injurious to Vegetation", 1852; Fitch's "First Report on the Insects of New York", 1856; Riley's, "First Report on the Insects of Missouri", 1868; Bulletin 8 of the Division of Entomology, U. S. Department of Agriculture, 1885, and the Annual Report of the Commissioner of Agriculture for the same year. Much additional information is given in Bulletin 14, New Series, also of the same Division, which constitutes by far our most comprehensive publication on this insect. In this paper, the author, Mr. C. L. Marlatt, has given an extended account of this species, and has brought together a very complete bibliography. Those interested in a fuller discussion of the periodical cicada than here given should, if possible, secure a copy of this paper.

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* In the more southern states the periodical cicada lives only 13 years, as explained on a later page. The seventeen year race, however is the one referred to in this bulletin since the thirteen year race does not occur, so far as known, within the State.

LIFE HISTORY AND HABITS.

As already mentioned, the most notable point of divergence in the life history of the periodical cicada, from that of other insects, is its long subterranean life. There are other species of insects whose larval period is known to extend over a period of from one to three years, as for instance the larvæ or grubs of the May beetle, which pass nearly three years in the soil, before transformation to the adult occurs. Also many wood boring larvæ of the family Cerambycidæ, and aquatic nymphs, of the Ephemeridæ, and those doubtless of other groups, require from one to three years for their growth. Comparatively little has been recorded relative to the longevity of insects after reaching maturity. The case of two queen ants, *Formica fusca*, as recorded by Lubbock may be mentioned as bearing on this point. In this instance the ants were taken in December, 1874, and were kept by him until July 1887, and August 1888, respectively, the dates of their death. The elder individual must therefore have lived for somewhat more than fourteen years. It is also stated that a queen bee has been kept in captivity fifteen years. Such instances are doubtless exceptional. In the present state of our knowledge the periodical cicada must be regarded as the longest lived of all insects.

The time of appearance of the cicada from its long stay under ground will vary somewhat, according to the altitude and latitude, being later in cooler sections, and earlier in those that are warmer. Despite this variation, however, there is a considerable degree of uniformity as to the time of their emergence, which throughout their range, as a whole, has been found to be the last week or ten days in May. The males precede the females as a rule, by several days, and disappear somewhat earlier for this reason, and also from the fact that they are shorter lived. Rather early in April of the seventeenth year of their lives, the pupæ make their appearance near the top of the ground. Leaving their old habitations, at a greater or less depth in the soil, they burrow upwards to within a few inches of the surface of the ground, where they remain during the month of April and early May, until quite ready for the final change. In this position they are frequently unearthed by digging or plowing, particularly under or near old trees. Hogs find them and the pupæ are eaten in great numbers to the considerable improvement of the swine. A mature pupa is shown in figure 1, about two thirds larger than natural size.

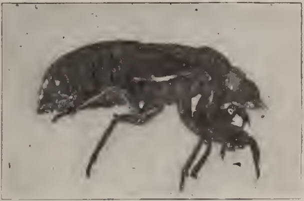


FIG. 1 —Full grown pupa of periodical cicada about two-thirds larger than natural size.

Some pupæ may build chimneys or cones of earth above their holes some weeks before issuing. These "cones", "towers" or "turrets", as they have been variously called, may vary from a mere rim of earth around the hole to a capped chimney, six or eight inches in height. Cicada chimneys were quite abundant in certain locations around College Park, the present season. In a piece of woods that had recently been burned over, they occurred in scattered patches quite up to the limit of the burned area. None were observed except where the ground had been swept by fire. The chimneys were, on the whole, quite short, the great majority being not more than one or two inches in height, and none were observed approximately more then four inches in height. Numerous theories have been advanced to account for the building of these mounds on the part of the pupa. In an extended review of the reported occurrences and explanations offered by different observers, Mr. Marlatt remarks "That the cone building habit is induced either by a shallow soil, proximity of the pupæ to the surface, or conditions of unusual warmth which brings the pupæ to the surface in advance of their usual time, and more rarely to unfavorable conditions of moisture." This hypothesis, as Mr. Marlatt states, is in effect a union of many of those already advanced, and is probably sufficiently general to include the real factors involved.

The Act of Transformation.

When the pupæ have finally reached that stage in their growth when they are ready to change to the adult condition, they take on considerable agility, leaving their holes, and scrambling pell mell for an elevated object near their former place of seclusion. Almost any object more or less elevated above their holes may be used as a support; weeds, bushes, mounds of earth, tree-trunks, fences and many other objects may be utilized. Where the pupæ have been abundant in the ground, the cast skins or molts may be very numerous. Under an old isolated apple tree, the "skins" were observed so numerous as to nearly cover the grass and weeds, and the limbs and lower branches were almost hid. Figure 2 illustrates an apple twig taken near College Park, bearing 13 skins and while not an exceptional instance in point of number, will serve to indicate in a measure the point under discussion. Professor Riley has most accurately described the several stages through which the insect go in the course of their development to the full fledged form. Some of these stages are shown in Plate I, which should be referred to in the reading of Professor Riley's description, which follows:

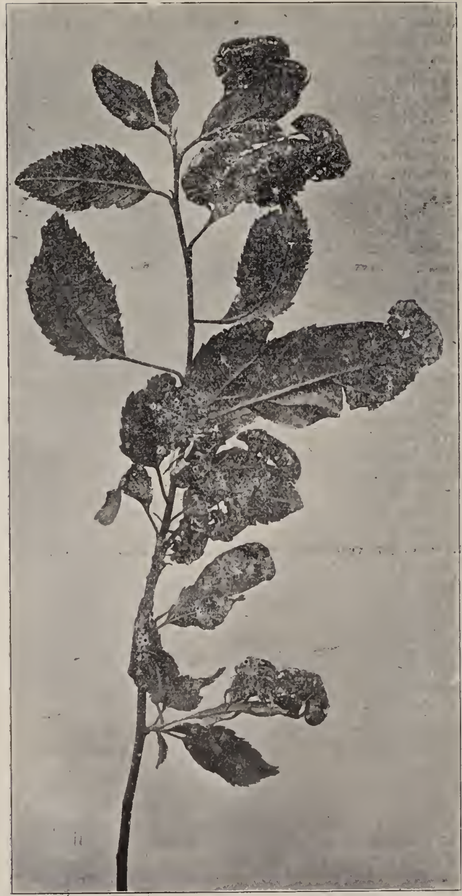


FIG. 2.—Apple twig bearing 13 "skins" or molts of periodical cicada.

"The unanimity with which all those which rise within a certain radius of a given tree crawl in a bee line to the trunk of that tree is most interesting. To witness these pupæ in such vast numbers that one can not step on the ground without crushing several swarming out of their subterranean holes and scrambling over the ground. all converging to the one central, point, and then in a steady stream clambering up the trunk and diverging again on the branches is an experience not readily forgotten and affording good food for speculation on the nature of instinct. The phenomenon is most satisfactorily witnessed where there is a solitary or isolated tree.

The pupæ begin to rise as soon as the sun is hidden behind the horizon, and they continue until by 9 o'oclock the bulk of them have risen. A few stragglers continue until midnight. They instinctively crawl along the horizontal branches after they have ascended the trunk and fasten themselves in any position, but preferably in a horizontal position on the leaves and twigs of the lowermost branches. In about an hour after rising and settling the skin splits down the middle of the thorax from the base of the clypeus to the base of the metanotum, and the forming Cicada begins to issue.

The colors of the forming Cicada are a creamy white, with the exception of the reddish eyes, the two strongly contrasting black patches on the prothorax, a black dash on each of the coxæ and sometimes on the front femora, and an orange tinge at the base of the wings.

There are five marked positions or phases in this act of evolving from the pupa shell, viz., the straight or extended, the hanging or head downward, the clinging or head upward, the flat winged, and finally the roof winged. In about three minutes after the shell splits, the forming imago extends from the rent almost on the same place with the pupa, with all its members straight and still hold by their tips within the exuvium. The imago then gradually bends backward and the members are loosened and separated. With the tip of the abdomen held within the exuvium, the rest of the body hangs extended at right angles from it, and remains in this position from ten to thirty seconds or more, the wing pads separating, and the front pair stretching at right angles from the body and obliquely crossing the hind pair. They then gradually swell, and during all this time the legs are becoming firmer and assuming the ultimate positions Suddenly the imago bends upward with a good deal of effort, and, clinging with its legs to the first object reached, whether leaf, twig or its own shell, withdraws entirely from the exuvium and hangs for the first time with its head up. Now the wings perceptibly swell and expand until they are fully stretched and hang flatly over the back, perfectly transparent with beautiful white veining. As they dry they assume the roofed position, and during the night the natural colors of the species are gradually assumed.

The time required in the transformation varies, and, though for the splitting of the skin and the full stretching of the wings in the flat position the time is usually about twenty minutes, it may be, under precisely similar conditions, five or six times as long. But there are few more beautiful sights than to see this fresh forming Cicada in all the different positions, clinging and clustering in great numbers to the outside lower leaves and branches of a large tree. In the moonlight such a tree looks for all the world as though it were full of beautiful white blossoms in various stages of expansion."

The Process of Egg-Laying.

Shortly after emerging the adults begin the work of egg-laying the real purpose of their brief aerial life of about six weeks. Within two weeks after their appearance, egg slits may be noticed, and rapidly become increasingly abundant. The female is not particularly choice in her selection of plants as repositories for the eggs, as many observers have noticed. A preference, however, seems to be shown for the oak, chestnut and hickory among forest trees, and for the apple and peach among fruit trees. But almost any tree, shrub or even herbaceous plants may be used, it being more a question of availability than anything else, and the most convenient plant is likely to be used. That they are not particularly discriminating may be judged from the fact that, according to Mr. Hunter Nichols, as recorded by Marlatt, the females were seen attempting to oviposit in the iron rod of a bridge. The part of the plant selected is more usually the one, or less usually, two year old wood, as these are yet sufficiently soft to be readily penetrated by the ovipositor, and suf ciently large to answer the purpose of the insect.

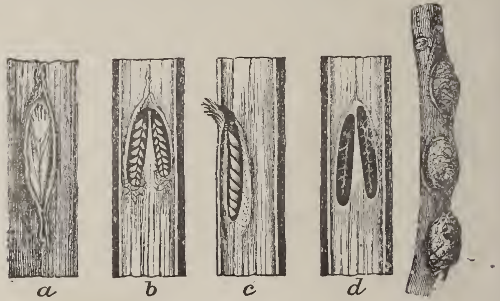


FIG. 3.—Egg nests of periodical cicada. (After Riley)

The eggs are laid in the twigs in two close, slightly converging row as shown in figure 3. The ovipositor is a strong instrument composed three pieces, a central, and two lateral blades which slide up and down it, and which have saw like teeth on the edges. The method of makin these slits is interesting, and has doubtless been observed by many th past summer. When ready to oviposit, the insect raises her body som what, placing the tip of the instrument against the twig, and incline about at an angle of 45°. The ovipositor is slowly forced into the woo the two lateral saw tipped blades working alternately. In figure 4, cicada is shown in the operation of egg laying in a maple twig.. Whe the ovipositor has been fully inserted, it is raised up in such a mann as to loosen the numerous little fibers of wood cut loose by the instrumen These are plainly evident projecting from the slit made by the inse slightly beyond the bark as shown in figure 5. In placing the eggs i the twig, the female first deposits one row, and then moves back, chan ing somewhat to one side and still keeping the ovipositor in the origin slit, proceeds to deposit a second row of eggs. As shown in figure 3, at and d, the two rows are slightly converging and separated by a partitio of wood.

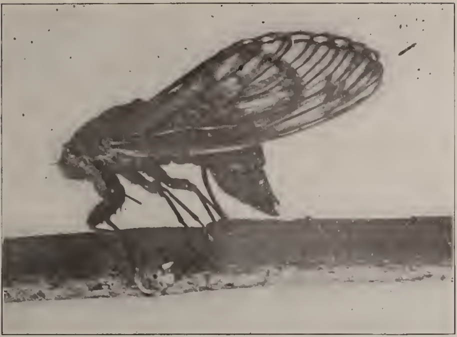


FIG. 4.—A female cicada in the act of egg laying. Enlarged about two thirds.

Observations made by Mr. I. H. Lawton, and reported by Professor Lintner, are to the effect that in the placing of a row of eggs, the female requires about 20 minutes, and for the complete double egg nest, about forty five minutes. A female was observed to make about eighty strokes per minute in cutting the fissure, and a short rest was taken after four chambers were cut. The number of slits made in a twig is quite variable, ranging from but few to very many. In fact a twig may be all but cut to pieces. A continuous slit two or three inches long may often be observed in a single twig. An individual egg nest may contain from fourteen to twenty eggs, or more. The female passes from one twig to another, or to other trees, until her eggs have been deposited. The total number laid by one insect has been placed at from four to six hundred. By the time these are all deposited, the female is quite exhausted, and may fall to the ground, where she soon dies, or is destroyed by some of her numerous natural enemies.

Injury to Plants From Egg Laying.

As previously noted almost any plant at hand may be made the receptacle of the eggs of the cicada. Usually the wood of the previous year's growth is chosen, two year old wood being disliked, as evidenced by the relatively few punctures made. On such favorite trees as the oak, chestnut, hickory, apple and peach, the effect of oviposition may be especially noteworthy. Where a considerable number of egg nests has been made in a twig, death may result, the leaves becoming brown and dry, and remaining attached to the twigs. Where the cicadas have been abundant, therefore, the trees may show a general brownish and dead appearance, due to the death of the injured terminal growth. In many parts of Maryland the present year, particularly in the mountain sections, so extensive had been the injury of this character that the landscape had taken on a browned and scorched appearance, as if a severe fire had raged through the trees. Many twigs may be so badly cut, that they break over and are soon carried to the ground by the action of the wind. These are particularly noticeable in forests after a heavy storm.

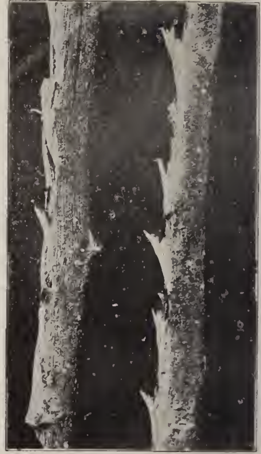


FIG. 5.—Twigs showing egg punctures of cicada.

It should be stated that the eggs in the dead or fallen twigs do not hatch, as some have supposed, except probably in instances where the embryo was already far advanced, but shrivel and die on account of the absence of moisture in the twigs. The falling of the twig is therefore an accident fatal to the insects, and is not a necessary occurrence in the life history of the species, as may have been supposed by some. Although many twigs thus fall to the ground the quantity is comparitively small, to those that remain, though badly punctured. Probably ninety per cent of all the eggs deposited are in twigs, which though more or less injured, are never broken off.

The injury inflicted by the cicada in the course of egg laying, is, [in effect, of two sorts. Where the terminal twigs eventually die, from excessive oviposition, a more or less general pruning is the result, and the injury is not particularly serious. In the case of other twigs and limbs however, while not killed, they may be so badly wounded that their future strength is greatly lessened. Such twigs in their subsequent growth, become much deformed, and at the point of injury become knotty, similating somewhat the appearance of injury from hail. While the exterior indications of injury may eventually largely, or quite disappear in the course of the growth of the surrounding wood, there will remain a dead and weakened area in the centre of the branch, which under the strain of high winds or heavy fruit crops, in the case of fruit trees, may break to the considerable injury of the tree. The open wounds or dead spots, furthermore, are a constant source of weakness. from the danger of entrance of fungi, or wood boring insects. In the case of apple trees, as pointed out by Doctor Hopkins, such wounds are favorite places for the development of colonies of the wooly aphis, which by the irritation of their beaks in the more tender forming bark, cause additional abnormal growth, thus interfering with proper and rapid healing over. Plate II, kindly furnished me by theWest Virginia Station, shows cicada injury on different twigs, and of various ages, and should be referred to in this connection.

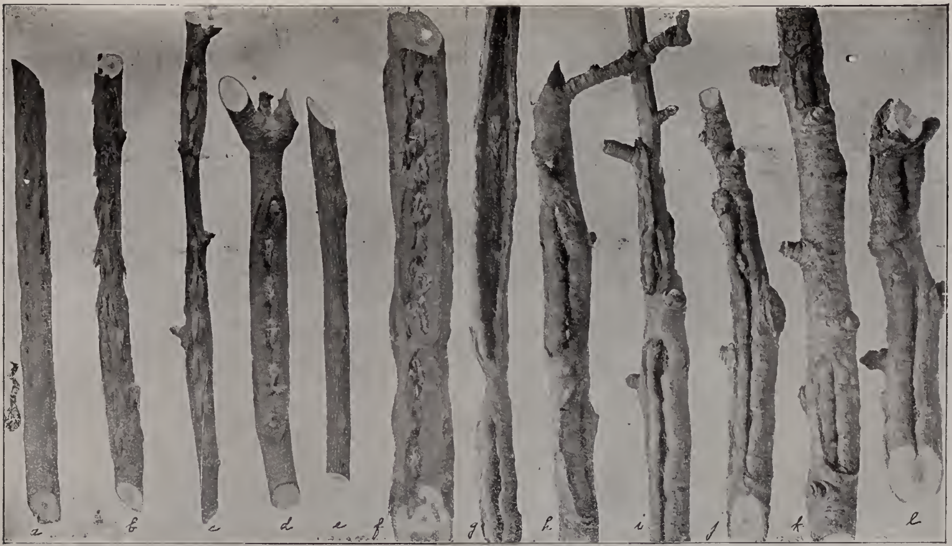


PLATE II.—Work of Periodical Cicada, a, fresh wound in maple; b, d, e and f, condition four months later, in maple; e, wound healed in one season; c, three months old scar in wild cherry, showing that the punctures may extend both toward the top and base of the twig; g-l, Cicada scars seventeen years old on terminal branches of old trees; g, h, i, apple; j, k, l, pear.
From Hopkins, West Virginia Station, Bulletin 68.

Feeding Habits of the Adult Cicadas.

It has been generally held by entomologists and others, that the adult cicadas feed but little, if at all. There are recorded observations, however, to the effect that the insects feed, after the usual manner of Homopterous insects, by thrusting their setae down in the plant tissues, and sucking up the sap. The mouth parts of the adults are certainly sufficiently developed for feeding, but considerable doubt has been expressed, if this were ever used for this purpose, particularly on the part of the males. Marlatt, in his excellent treatise of this species, states, after reviewing the literature bearing on this point, (Bull. 14, N. S. Div. Ent. U. S. Dept. Agric. p. 72): "The taking of food in the adult stage seems to be of rare occurrence, and has been observed and commented upon by a few of the entomologists, who have studied the species. That the periodical cicada feeds at all has even been questioned, and it is quite possible that in some of the cases where it was supposed to have been feeding the action of the insect was misinterpreted. Such feeding is limited, at any rate, to the female, as in this sex only do we find a perfect digestive apparatus, that of the male being rudimentary."

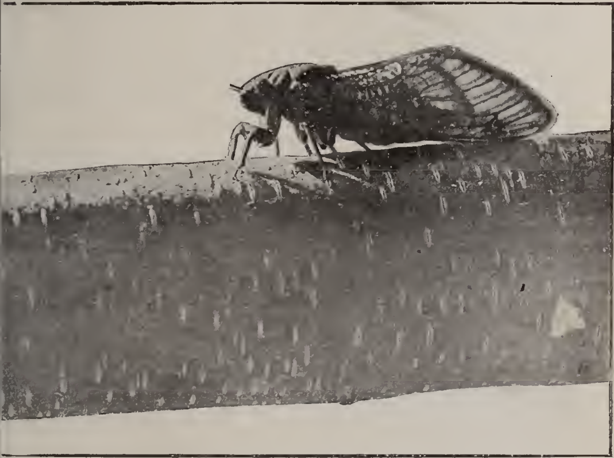


FIG. 6—Cicada in the act of feeding.
(From Quaintance, Bulletin 37, U. S. Div. Ent. U. S. Dept. Agric.)

Early in June of this year, the writer in company with Mr. F. H. Blodgett, and Mr. R. I. Smith, in visiting a young apple and pear orchard, at College Park, observed the cicadas feeding along the trunks and larger limbs of the trees in considerable numbers. The accompanying illustration, figure 6, from a photograph made by Mr. Blodgett, shows a cicada in the act of feeding. The beak is extended directly towards the bark, and the setæ, though not apparent in the picture, are thrust into the tissues of the plant. That the insects were not merely resting their beaks against the bark was frequently determined by disturbing them, when the withdrawal of the setæ could be plainly observed. By the use of a fine pair of scissors, it was possible to snip off the beak of the insect while in the act of feeding, thus leaving the beak imbedded in the plant. By cutting out the small block of wood bearing the beak, and sectioning with a microtome or razor, the setæ were exposed in the identical position which they occupied in the plant when the insect was feeding. Figure 7 is from a photomicrograph of the tip of the beak and setæ of a male cicada thus prepared. Figure 8 shows the head of a cicada, the three setæ having been dissected from the sheath like beak, much enlarged. Many preparations similar to that shown in figure 7, of both sexes, have been prepared. That the insects actually feed in the strict sense of the word, that is take up sap from the tree, there is good evidence. Numerous examples, both males and females, have been taken in the act of feeding, and quickly opened, in many of which the crop or stomach would be found distended many times the normal size, with a liquid, presumably the sap from the tree. Numerous dissections of fresh specimens of both sexes, under water, also show that the alimentary canal is not rudimentary in the male, but is practically as well developed as in the female. The intestine, in both sexes, is small and thread like, but continuous, and sufficiently developed for insects subsisting on liquid food.

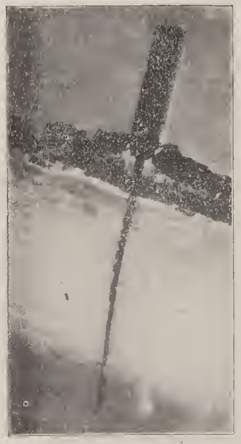


FIG. 7.—Showing position of beak and setæ of periodical cicada in bark and wood of tree as in feeding. Greatly enlarged.

Not only were the cicadas observed to be feeding quite generally at College Park, but also in many parts of the state where my work has taken me, I have found them feeding, frequently in considerable numbers. In the mornings or evenings, the insects were observed feeding most numerously. The withdrawal of the beak of the insect from the plant is usually followed by the exudation of a greater or less quantity of sap from the puncture. It was common to find trees with the trunk and larger limbs quite wet with the sap which had escaped in this way. Many orchardists have noticed this the present year, and some have understood its cause. Many, however, have not attributed the wet trunk and limbs to the work of the cicada, from the prevalent opinion that these insects take no food in the adult stage. Feeding was also noticed to be quite general in the higher parts of the large oak and hickory trees surrounding the College buildings. By the use of an opera glass, from the upper stories of these buildings, the insects were observed to be quite abundant, feeding along the smaller branches and limbs. In young orchards, in locations where the insects are quite numerous, it would seem that injury might result from the extraction of sap by the adults, and its escape from the punctures made.

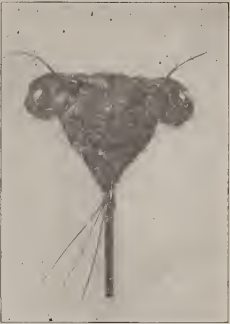


FIG. 8.—Head of cicada, showing beak with setæ dissected. Much enlarged.

The Song of the Cicada.

Only the male cicada sings, hence the couplet:

"Happy the cicadas' lives,
For all have voiceless wives."

The sound is produced by two shell like inflated drums, situated, one on each side of the basal segment of the abdomen. By reference to figure 9 the reader may see an enlarged photographic illustration of the exterior of this apparatus. The fluted timbal, seen in the illustration, is caused to vibrate by powerful muscles within. The sound thus produced, much after the manner of pushing in and out the bottom of a tin pan, is variously modified by certain smaller disks or sounding boards. The "song" is also modified by the raising and lowering of the abdomen. "The male, in singing", it is stated by Marlatt, "always rests with the head upwards, The abdomen is then elevated and apparently inflated and with the beginning of the sound is slowly brought down against the limb, when the note ceases. After a rest of a few seconds, this operation is repeated." The peculiar notes of the different species of cicadas are produced to some extent by a difference in the movement of the abdomen.

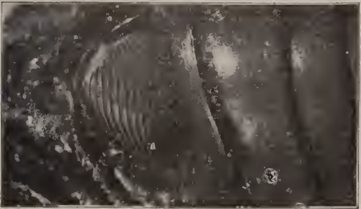


FIG. 9.—The musical apparatus of the periodical cicada. Much enlarged.

Does the Cicada "Sting"?

Strictly speaking, the cicada is not able to sting from the fact that it is possessed of no organ adapted to this purpose. It is possible, however, that with the needle like filaments or setæ of its beak, shown dissected in figure 8, the insect might pierce the flesh of persons handling it. That this may occur at times, there seems some evidence, but there is no reason to believe that in such cases the piercing of the flesh is attended with an injection of poison. The results following such attacks should, in the case of a person whose blood is in a healthy condition, produce no more serious results than that attending puncturing the skin with a needle. The extreme cases reported following the "sting" of the cicada, are doubtless due to the over sensativeness of the persons concerned, and to an impure condition of the blood. Under such conditions, the bite of a flea or mosquito, commonly trivial enough may be attended with results quite out of proportion, and well authenticated instances are not wanting of serious, if not fatal results, from bites of these insects. The possibility of the use of the ovipositor as a puncturing organ has been removed, in an experimental way, by tests made by Professor Riley and others, the female being apparently not able to penetrate the soft, yielding flesh with this instrument. The instances of injury from the cicada that are reported during every cicada year, are therefore doubtless entirely due to the puncturing of the flesh by the needle like mouth parts, and are quite likely accidental on the part of the insect, The writer has handled thousands of these insects, and despite numerous attempts, has never been able to provoke them to use the setæ as a defensive organ. No insect is more helpless, and they may be handled with impunity.

Habits of the Larva and Pupa.

The eggs of the periodical cicada hatch in from six to seven weeks. The young larvæ are from the start quite active, and soon after escaping from the egg shell, loosen their hold on the twig or branch and fall to the ground. Here they at once work below the soil, frequently in some crack or fissure, thus beginning their long subterranean existence. They soon establish themselves in small earthen cells, adjacent to the roots or rootlets of plants from which nourishment is secured, by sucking the sap with their thread like setæ. Growth is very slow, and the cell at first is not larger than a bird shot, but is gradually increased in size to accommodate the growth of the insect. From time to time, the insects doubtless burrow in the soil from one place to another, and this with the work of feeding, constitutes their principle activity. The depth to which they may burrow, is, from all observations, quite variable. Cases are on record where larvæ have been found at a depth of ten or even more feet, but these must be regarded as exceptional. The majority of observations go to show, that as a rule, the insects are to be found within two feet of the surface of the ground, and most abundantly within a range of from eight to eighteen inches. Although frequently occurring on the roots

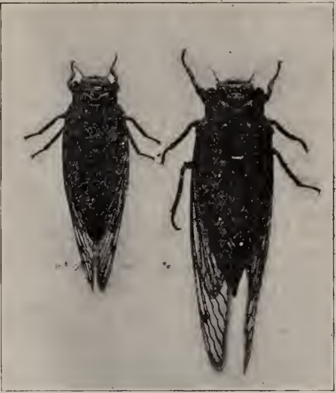


FIG. 10.—The dwarf variety and normal form of cicada. Enlarged about two-thirds

of trees in enormous numbers, but little, definite injury has been attributed to them. In many instances, the ground under insolated forest or fruit trees the present season, was observed to be literally covered with the shells of the insects, and thoroughly perforated with their holes. Yet notwithstanding the myrids of larvæ and pupæ, which must have inhabited the soil under the trees and fed on the roots, no indications of injury were to be detected, as indicated by the general health of the tree. One case of apparent injury, however, is mentioned by Miss Morris in Proc. Acad. Nat. Science, Philadelphia, 1846, Vol. 3, p. 133, which seems to indicate that injury may follow their presence. Miss Morris says in referring to a sickly tree:

> "Agreeably to my expectation, I found the larvæ of the cicada in countless numbers clinging to the roots of the tree, with their suckers piercing the bark and so deeply and firmly placed that they remained hanging for half an hour after being removed from the earth. From a root a yard long and about an inch in diameter, I gathered twenty three larvæ; they were of various sizes, from a quarter of an inch to an inch in length. They were on all the roots that grew deeper than six inches below the surface. The roots were unhealthy and bore appearance of external inqury from small punctures. On removing the outer coat of bark this appearance increased. leaving no doubt as to the cause of the disease."

In this connection it should be remembered that the development of the cicada is very slow, and that the food required for many other rapid growing insects to attain their growth, is here consumed only during a period of seventeen years, and hence the amount taken from a plant would be, at any one time, quite infinitesimal. There are also doubtless, considerable periods of dormancy, particularly during the cooler seasons of the year, when no food at all is taken. It may therefore be safe to assume, in the absence of more exact data to the contrary, that comparatively little injury results from the presence of cicada larvæ on the roots of trees, although they may be present in large numbers. Mr. Marlatt has shown, that despite their long adolescent period, the insect presents the same number of molts or stages as other species, whose life circle may be run in a few weeks. Six distinct nymphal stages have been described, four of which belong to the larval, and two to the pupal period.

The adaptability of the insect to its underground life may be readily observed by reference to Figure 1, illustrating a fully developed pupa. It will be seen that the fore legs are strong and well fitted for burrow-ing. This characteristic is true of all the immature stages, the young larva, just as it comes from the egg, having the stout tibial claws with which to burrow beneath the soil.

THE TWO RACES OF THE CICADA.

It is perhaps a generally well known fact that in the more southern part of the United States, the seventeen-year race is replaced by a thirteen-year race; that is, the periodical cicada in these States reaches maturity in thirteen years. Some entomologists have held the thirteen year race to represent a distinct species of insect, and it has been designated *Cicada tridecim* on this account. Doctor Walsh was strongly of this opinion, and his position has been upheld by Mr. Wm. H. Ashmead of the U. S. National Museum, who, in the course of a careful examination of the material in the National Museum, found slight, but constant differences between specimens of the two races. This considerable difference in the life cycle of the two races, however, seems to be the most important point of divergence, and Marlatt is of the opinion that the thirteen-year cicadas should be considered a race merely, or an incipient species.

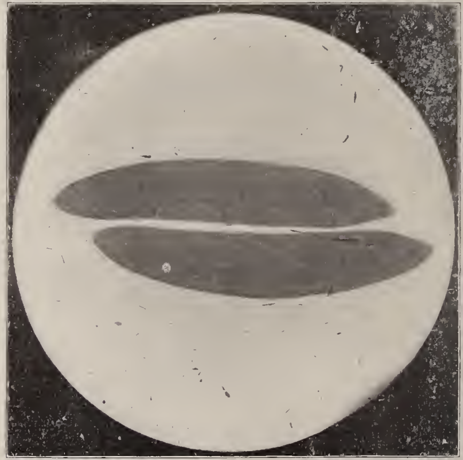


FIG. 11.—Photomicrograph of two eggs of the cicada. Greatly enlarged.

The explanation of this peculiar phenomenon is most probably to be found in the effect of the greater warmth of the climate in the South, resulting in a more rapid growth and maturity. This is in harmony with the well known effect of increased warmth on animals, and plants as well. The variation in question, however, probably occurred some considerable time in the past, and the races seem now to be quite distinct, showing no tendency to intergrade in the way of interbreeding, in regions where the races overlap. Interesting experiments are reported by Mr. Marlatt, where the seventeen-year race has been established in the South, and the thirteen-year race in the North, to determine the effect of the change of climate on hastening or retarding the period of emergence. While it was not expected that the time of development should be changed in a single generation, yet a difference of a year or more, earlier or later, has been looked for.

THE DWARF VARIETY.

It is also interesting to note that there are two distinct forms or varieties of adult cicadas, occurring in both the seventeen-year and thirteen-year races. The two varieties are easily distinguished by their size, and are shown in figure 10, the dwarf being on the left, and the normal form on the right. The large form comprises the bulk of the swarm, the dwarfs being, as a rule, later and frequently unobserved. Doctor Hildreth recognized the existence of these two forms as early as 1830, and in 1851, the smaller form was described by Fisher as a distinct species, under the name *Cicada Cassinii.* Considerable contention has resulted as to whether or not the insect was entitled to specific rank. In more recent years, it has been considered as a variety, or form only. In the small form, as would be expected, the males have quite a different song note from the familiar f-a-r-r-o sound of the normal cicada, it being quite shrill, and readily recognized.

DESCRIPTION OF THE DIFFERENT STAGES.

The Egg.—The egg of the cicada is about one-twelth of an inch in length, oblong, and slightly curved in shape, tapering on each end to an obtuse point. In color, it is at first pearly white, but gradually assumes a darker hue, as the development of the embryo advances. In common with many other species of insects, which deposit their eggs in plant tissues, the eggs of the cicada increase somewhat in size, owing to the absorption of juices from the surrounding plant cells. As has been stated, the eggs are deposited, in Northern latitudes, largely during June, and oviposition is probably at its heighth during the middle of this month. Hatching may begin about the middle of July, extending to the first of August, or possibly later. When sufficiently developed, the embryo larva makes its escape from the delicate shell by rupturing it over its back, and by much wriggling and contortions, finally gets free and crawls out on the twig in which the eggs were situated. Figure 11 illustrates two eggs of the cicada much enlarged, reproduced from a photomicrograph.

The Larva and Pupa.—The larva, as it comes from the egg, is quite small, measuring not more than one-sixteenth of an inch in length. The body is slender, creamy white in color, and sparsely covered with hairs. It has been compared in this stage to an ant, but the resemblance of course is only superficial. As in all of the immature stages, the lobster-like front legs are present, which serve to give it quite a grotesque appearance. After hatching, the larvæ soon drop to the ground, which from their lightness, they reach without injury, and soon disappear beneath the surface. Growth is quite slow and the larvæ undergo four molts in arriving at the first pupal stage. These, with two subsequent molts, before the adult condition is reached, makes the number the same

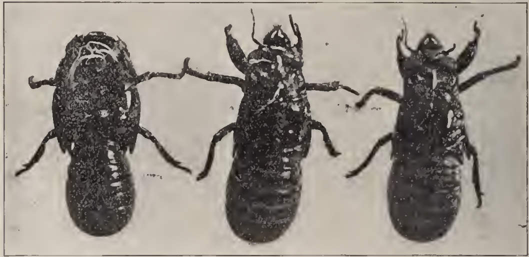


FIG. 12.—Three "skins", or molts of periodical cicada Enlarged about two-thirds,

as with most other species of this group. It has been supposed, owing to the long period of growth of this species, that the skin would be cast or shed a considerable number of times. In 1881, Doctor Riley in Missouri, undertook to follow out the life of the larva, until it emerged. This work was later turned over to Mr. Bartow, who made observations until 1891. These and later investigations by Mr. Marlatt, have resulted in a knowledge of the approximate length of the respective larval and pupal stages, which have been given by Marlatt substantially as follows:

(1) The first stage lasts more than a year, the first molt usually occurring during the second year after hatching.

(2) The second stage is entered during the first two or three months of the second year of the insects existence, and continues for nearly two years.

(3) The larva is in the third stage at the completion of the fourth year of its existence.

(4) In the fourth stage the larva is at the completion of the eighth year of its life, and this stage probably lasts for three or four years.

(5-6) Following the fourth larval stage, the first pupal period is entered. During the pupal period of some six or seven years, the insect molts twice, the last molt being above ground and just as the insects are emerging into the adult condition.

The casts or skins, thrown off in the last molt, are in the case of a large brood, exceedingly abundant, and are left clinging to leaves, the trunks of trees, bushes, or scattered thickly over the ground. See figure 12, illustrating three casts, seen from above.

The pupa resembles the larva to a considerable extent, except that the red eye spots are absent, and the true compound eyes are more prominent. The rudimentary wings are plainly evident, two on each side. The front legs are well developed and fitted for digging. A pupa in its second stage, and almost ready for the final molt into the adult condition, is shown in figure 1, about two-thirds larger than natural size.

The Adult Cicada.--During May or June of the seventeenth-year of the cicadas existence it sheds its skin for the last time, and attains the adult condition. Figure 13 illustrates an adult as it is working its way out from the pupal shell; the several stages in this process may be seen by referring to Plate As it first emerges, the body is soft, and creamy white in color, the wings being much folded, and useless. But in the course of a night, the skin hardens, becoming jet black in color, and the wings expand to their normal size and shape. The body on the whole is black with the exception of the eyes, legs, and principal veins of the four membranous wings, which are orange-red in color. When at rest, the wings are held roof like over the body, projecting beyond the tip of the abdomen about one-half an inch. The body of the female is about an inch in length and the wings when expanded, measure about three inches from tip to tip. Figure 14 illustrates a female, somewhat enlarged, with the wings expanded. Near the tip of each fore wing, a small letter "w" may be observed. Two specimens are shown in dorsal and lateral aspect respectively, in figure 15, somewhat enlarged.

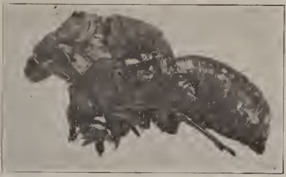


FIG. 13.—Cicada in the act of transforming from the pupal to adult condition. Enlarged about two-thirds.

The male and female cicadas are readily distinguished by even a casual examination. The presence of the ovipositor in the female, and of the song apparatus in the male, being the most available characters. In figure 16 the two sexes are shown with the wings removed, the lower individual being a female and the upper, a male.

DISTRIBUTION.

The periodical cicada, in its natural distribution, occurs only in the United States, and has been recorded in greater or less numbers from all states east of the Rocky Mountains, except the states of Vermont, Maine and New Hampshire. Somewhere throughout its range the insects appear every year.

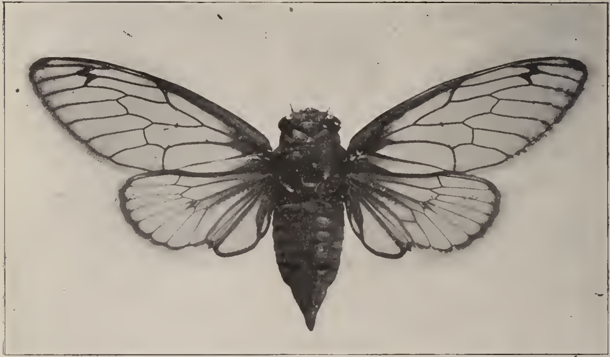


FIG. 14—Adult female cicada with wings expanded. Enlarged about two-thirds.

CLASSIFICATION OF THE DIFFERENT BROODS.

The earlier entomologists designated the different broods according to the years of their appearance. Somewhat later a numbering system was introduced by Dr. Fitch, including nine broods only. Riley placed the number of broods at twenty two, and later investigations by Mr. Marlatt have raised this number to thirty, and a new enumeration has been proposed. The new nomenclature suggested is given in the following table, beginning with the year 1893, when the initial broods of both the seventeen year and thirteen year series appeared in conjunction. The corresponding nomenclatures proposed by Professor Riley, by Walsh and Riley, by Fitch and the year records in Doctor Smith's register are given in parallel columns.

TABLE I.

Nomenclature of the Broods of the Periodical Cicada.

Year.	Broods of the seventeen year race.					Broods of the thirteen year race.				
	Proposed enumeration.	Riley's numbers.	Walsh-Riley numbers.	Fitch numbers.	Smith register.	Proposed enumeration.	Riley numbers.	Walsh Riley numbers.	Fitch numbers.	Smith register.
1893	I	XI	——	——	1842	XVIII	XVI	——	——	1854
1894	II	XII	VIII	1	1843	XIX	XVIII	XIII	3	1842–1855
1895	III	XIII	IX	——	1844	XX	II	——	——	1843
1896	IV	XIV	X		1845	XXI	IV	——	——	1844
1897	V	XV	XI	——	1846	XXII	VI	IV	——	1845
1898	VI	XVII	XII	7	1847	XXIII	VII	V	5	1846–1859
1899	VII	XIX	——	——	1848	XXIV	——	——	——	——
1900	VIII	XX	XIV	2–8	1849	XXV	——	——	——	——
1901	IX	XXI	XV	5	1850	XXVI	X	——	——	1849
1902	X	XXII	XVI	4	1851	XXVII	——	——	——	——
1903	XI	I	I	9	1852	XXVIII	——	——	——	——
1904	XII	——	II	——	1853	XXIX	——	——	——	——
1905	XIII	V	III	6	1854	XXX	——	——	——	——
1906	XIV	VIII	VI	3	1855	XVIII	XVI	——	——	1854
1907	XV	——	——	——	——	XIX	XVIII	XIII	3	1842–1855
1908	XVI	IX	VII	——	——	XX	II	——	——	1843
1909	XVII	——	——	——	——	XXI	IV	——	——	1844

NATURAL ENEMIES OF THE CICADA.

The peculiar life history of the periodical cicada protects it to a considerable extent from the degree of loss to which insects of the more usual mode of life are subject. A parasitic species, subsisting only on the eggs or adults of the cicada would perish during the long intervals between the appearance of their hosts. The parasites and predacious insect enemies of the cicada are therefore largely, if not entirely those of general feeding habits, and turn their attention to the eggs or adults on account of their abundance. In the egg state the cicada is subject to the attack of certain parasitic flies, as well as predacious species of the orders Coleoptera, Hemiptera and Neuroptera, and the mites among the Acarina. The adult insects are practically helpless. and fall an easy prey to insectivorous mammals, reptiles, birds and predacious insects. Birds particularly destroy them in large numbers, and in the vicinity of cities and towns, they have been in some cases practically exterminated by the English sparrow. Chickens and other fowls are very fond of them, and during the prevalance of the cicada, they subsist largely on them. The adults are subject to a fungous disease which under proper weather conditions, may destroy them in great numbers. The pupæ, as they approach the surface of the ground during April and May of their seventeenth year, are rooted out and devoured in large quantities by hogs, and the young larvæ, as they hatch and fall to the ground, are preyed upon by Coleopterous larvæ and other predacious insect forms. That the adults are also the victims of adverse weather conditions was witnessed the present season. The heavy rain and wind of Sunday, June 8th, was most fatal to the insects throughout the range of its occurrence. At College Park the ground was strewn with their dead bodies, and reports from various parts of the

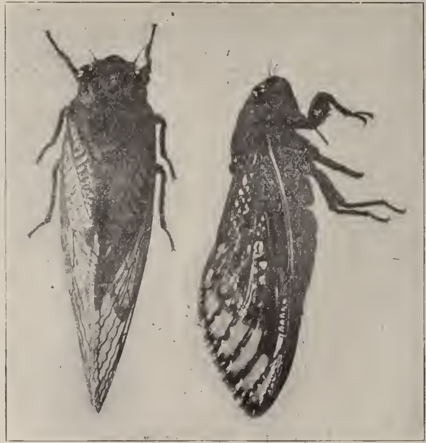


FIG. 15—Two cicadas shown in dorsal and lateral aspect. Enlarged about two-thirds.

state were to the effect that the destruction had been very severe. The effect of the storm and the cold weather following, was noticeable for days, and woods which previously had been filled with their noise was comparatively silent. Undoubtedly, however, the most important factors tending to decrease the relative abundance of this species in its successive broods, are those due to the actions of man himself, such as the clearing and cultivation of lands. As the development of a section increases the cicadas become less and less numerous, and it is a fact, not without regret to the naturalists, that the advance of civilization witnesses the gradual extinc-on of this very anomolus insect, whose song and peculiar life must have been heard and noted by the primaeval inhabitants of the continent in the ages past and gone.

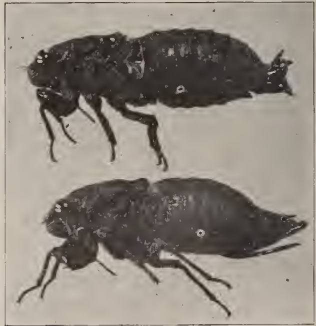


FIG. 16—The two sexes, in lateral view,with wings removed. Female below. Enlarged about two-thirds.

OTHER BROODS OF THE CICADA IN MARYLAND.

There are other broods of the cicada occurring in the State in addition to brood X, which has just passed, though this latter is much the largest and most generally distributed. Owing to their comparatively restricted territory, the swarms have attracted but little attention.

Considered chronologically in the order of future appearance, the broods may be cited as follows: Brood XIV is scheduled to appear in Washington county in 1906.

Brood I, due to appear in 1910, will occur in Prince George's county and lower half of St. Mary's.

Brood II, occurring in 1911, will appear in Anne Arundel, Calvert, Charles, Prince George's and Saint Mary's counties. The insects appeared last in 1894.

On the authority of Mr. J. A. Dixon of Friendsville, Garret county, Brood V must also be recorded for the extreme western part of the State. This brood last appeared in 1897, and is hence due to appear in 1914. From its occurrence in adjoining counties in West Virginia, its appearance in Garrett or Allegany counties in Maryland, was to be looked for but this appears to be its first record for the State. Mr. Dixon also mentions a swarm in 1890. No brood seems to be recorded for this territory during that year. Brood XIV, scheduled for Washington county in 1906, ast appeared in 1889, and it is possible that the 1889 swarm is the one observed, there being a mistake of one year in the date. On this supposition the range of brood XIV in Maryland becomes somewhat extended.

In addition to recording the 1894 swarm of brood II, Mr. W. S. Clopper of Valley Lee in Saint Mary's county, states that the "fly" was very numerous and destructive in 1887. This is possibly a part of Marlatt's brood XII.

THE 1902 SWARM, AND ITS DISTRIBUTION IN MARYLAND.

The recent swarm, which is brood X of Marlatt, is the largest of all broods of this species. Its distribution in the United States in 1885, the date of its last appearance, as determined from the records of the Division of Entomology of the U. S. Department of Agriculture, may be judged by reference to figure 17, which follows.

The insect was scheduled to appear in the following states: Alabama, Delaware, District of Columbia, Georgia, Illinois, Indiana, Kentucky, Maryland, Massachusetts, Michigan, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Tennessee, Vermont, Virginia, West Virginia and Wisconsin.

In the State of Maryland its occurrence was noted in the following counties in 1885: Allegany, Anne Arundel, Baltimore, Caroline, Carroll, Cecil, Frederick, Garrett, Harford, Howard, Kent, Montgomery, Prince George, Queen Anne, Talbot and Washington.

In order to determine as accurately as possible the occurrence and relative abundance of the cicada in the various counties in the state, 500

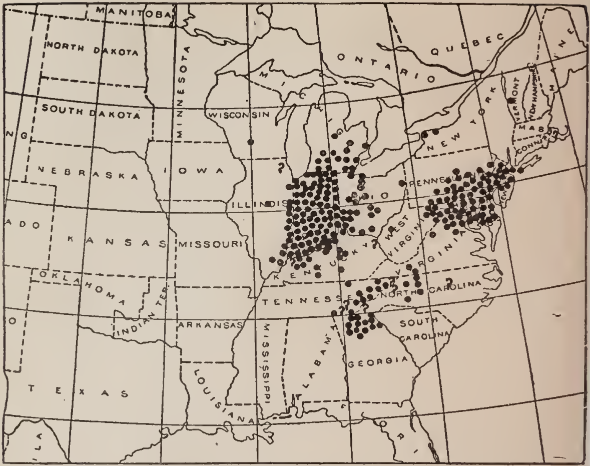
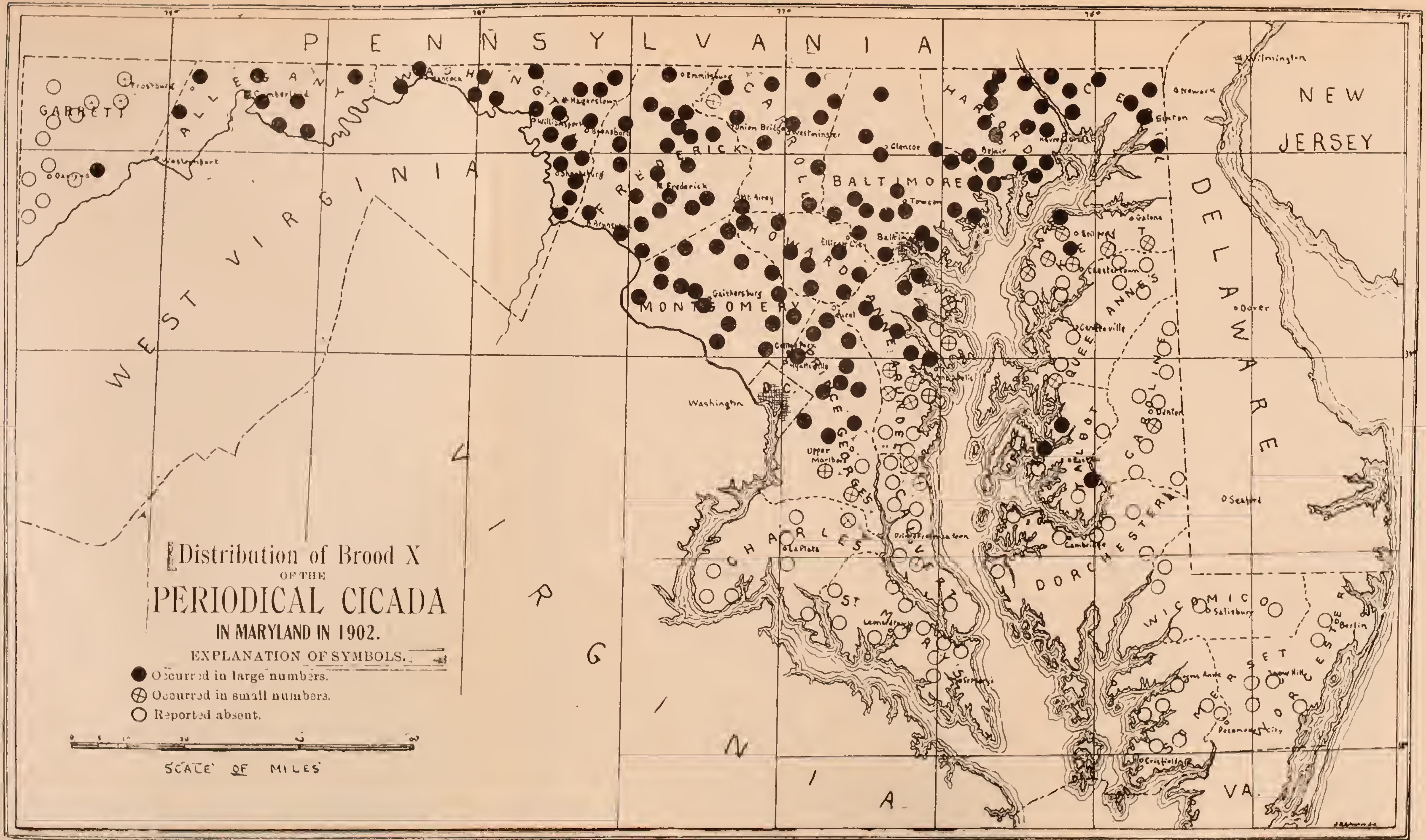


FIG. 17—Map showing distribution of Brood X of periodical cicada in the United States in 1885. (After Marlatt).

return postal cards were sent out June 4th, with a request for informa-on the occurrence, relative abundance, date of appearance or absence of the insect, in the respective localities. The postals were distributed as generally as possible over the state, so that all sections could be heard from. A large majority of the cards sent out were returned, and much interesting data thus secured. The observations thus obtained have been arranged in tabular form, and are presented in Table II. I have also had access to the data secured by the Climate and Crop service of the U. S. Weather Bureau, from their voluntary observers, and I desire to here acknowledge my indebtedness to Prof. Oliver L. Fassig, Section Director of the Maryland and Delaware Section, for placing these observations at my disposal. The data have been incorporated in the tabular synopsis already referred to.

In the accompanying map, Plate III, I have designated as accurately as possible, by a solid dot, the location of post offices from which reports were received, or personal observations made, of the presence of the cicada in considerable to larger numbers.

Those post offices from which the cicada was reported in comparatively small numbers are indicated by an x-circle, and those from which negative reports were received, are indicated by a simple circle. More specific information concerning any section of the State may be obtained by reference to the following table, arranged alphabetically according to counties and postoffices.



Distribution of Brood X OF THE PERIODICAL CICADA IN MARYLAND IN 1902.

EXPLANATION OF SYMBOLS.

- ● Occurred in large numbers.
- ⊗ Occurred in small numbers.
- ○ Reported absent.

TABLE II.

A Tabular Synopsis of Reports of Correspondents Relative to Occurrence of the Periodical Cicada, Arranged Alphabetically According to Counties and Post Offices.

Counties and Post offices.	Observers.	Date of Report	Remarks of Observers.
ALLEGANY.			
Cumberland,	Robt. R. Hebdeis,	May 29	"Abundant among trees. Appeared two weeks ago."
Cumberland,	F. F. Brown,	....	"Locusts are plentiful and destructive to all trees."
Cumberland,	Fred. Perry,	June 30	"They first made their appearance in numbers May 20th, and began to disappear June 20th. Very little or no damage was done."
Cumberland,	F. B. Reid,	June 5	"Locusts over everything in sight. Appeared about two weeks ago."
Frostburg,	C. A. Murphy,	June 3	"Appeared about May 24th in considerable numbers."
Hazen,	H. W. Parker,	June 6	"Very abundant appearing all during May."
Lonaconing,	Jacob Miller.	June 7	"Numerous in our vicinity."
Piney Grove,	J. T. Hartley,	May 30	"Not quite so numerous as in past years."
Rush,	D. D. Pennel,	May 31	"They are here in large numbers, but confined chiefly to heavy timber."
ANNE ARUNDEL			
Annapolis,	Q. M. Abbott,	....	"Appeared May 27th and 28th in abundance about Waterbury, Millersville and through that section. Not destructive."
Annapolis,	J. R. Bean,	....	"Appeared about ten days ago. No damage has been caused by them as yet."
Bristol,	E. O. Welch.	....	"No locusts have appeared."
Davidsonville,	S. C. Jones,	June 6	"Not very numerous. Not more so than seventeen years ago."
Elyaton,	T. B. Johnson,	July 1	Locust reported present.
Friendship,	E. E. Buckhead,	June 4	"First heard June 1st, and only a very few then."
Harwood,	T. M. King.	....	"Appeared about three weeks ago. No damage."
Lakeshore,	Jeff. M. Cook,	May 30	"Have not seen or heard any of the locust this season and seventeen years ago did not hear over a dozen."
Jewell,	John Plummer,	May 30	"None seen or heard to date. Reported not nearer than Fosterville".
Maynards,	T. F. Bottomly,	May 30	"First seen May 15. Not plentiful, except in new cleared land."

TABLE II.—Continued.

Counties and post offices.	Observers.	Date of report.	Remarks of Observers.
Mayo,	Jas. Wagner,	May 30	"Have not seen a locust in this locality. One or two reported."
Patuxent,	R. K. Duvall.	....	"Appeared abundantly May 20th Young fruit and some shade trees show much dried twigs."
St. Margaret's,	H. A. Tydings,	May 30	"But one heard, and that on May 24th.'
South Baltimore,	Elias Stallings,	May 28	"Appeared here in large numbers about ten days ago."
Tracey's Landing	F. W. Hall,	June 1	"No locusts have appeared in this locality as yet."
Wellhams,	J. S. Linthicum,	May 29	"Locusts made their appearance here 12 or 15 days ago. At first very few but now very plentilul."
BALTIMORE.			
Arlington,	E. A. Seidewitz,	May 29	"Arrived about three weeks ago in large numbers."
Balto. (Pat'n Park),	C. L. Seybold,	May 28	"Appeared in considerable numbers in East Baltimore District. First noticed in Patterson Park May 16. Not as numerous as 17 years ago."
Baltimore,	B. F. Taylor.	....	"Appeared in 11th District, Bradshaw, June 1st. Not so numerous as in previous years and damage not materially destructive."
,	W. H. Evans.	July 1	"First noticed May 20th. Disappeared about June 25th.
Chase,	J. E. Wilkinson,	June 4	"Appeared here May 15th. Now present in large numbers, especially in apple orchards."
Fullerton,	A. McCormick.	....	"Appeared in great numbers May 18th in apple orchards only. Damage slight"
Fork,	C. Snavely,	....	"Appeared four weeks ago and are not so numerous. No noticeable damage has been done, unless the killing of the ends of twigs."
Gardenville,	C. T. Ward,	June 6	"Have appeared here in large numbers."
Grange,	J. M. Diehl,	May 30	'Locusts here in large numbers, mostly in the woods."
Kingsville,	E. Boll,	....	"Appeared about May 20th. Destructive to young trees"
McDonogh,	S. T. Moreland,	....	"Appeared in abundance about May 20th. Damage slight."

TABLE II.—Continued.

Counties and Post offices.	Observers.	Date of report.	Remarks of Observers.
Parkton,	A. H. Hayes,	....	"Appeared May 21st in large numbers. Young orchards are suffering greatly."
Pikesville,	S. A. Marshall,	May 29	"Appeared here in large numbers about two weeks ago."
Philopolis,	C. H. Price,	June 26	"First appeared May 23d. Did some damage to young apple trees."
Towson,	Thos. J. Lea,	June 2	"Very abundant. First deposit of eggs June 10th."
Towson,	D. H Rice,	....	"Appeared about May 20th in not as great numbers as in 1885. Have done some damage."
CALVERT.			
Bowens,	J. S. Hammett,	June 5	"No locusts seen or heard in this county thus far."
Chaneyville,	L. L. Chaney,	June 5	"Have not seen or heard of any locusts here this year."
Chaneyville,	R. Steuart,	....	"Locusts have not come. They have reached only to the Patuxent River. There they deposit their eggs on the branches of trees and no other damage was done."
Dunkirk,	J. W. Jones.	June 4	"No locust seen or heard of in this part of the county."
Dunkirk,	F. O. Smith,	June 2	"To date no locusts have appeared or been heard from in this section."
Huntingtown,	F. T. Harrison,	June 19	"Have not seen or heard any locusts myself. Some reported to have been heard."
Mutual,	W. H. Cranford,	June 11	"Haven't seen any locusts; but heard one May 13th."
Parran,	J. W. Cranford,	June 11	"Locusts to this time have not appeared here. It is said that a few have appeared in a meadow near here."
Prince Frederickt'n,	J. J. Dalrymple,	June 6	"The Periodical Cicada has not appeared in this vicinity this year."
Prince Frederickt'n,	W. F. Robinson,	June 5	"I have not seen or heard of any seventeen year locusts it this vicinity."
Prince Frederickt'n,	T. B. Taylor,	....	"Have not appeared in locality. Were present in 1894 and were very destructive to young trees."
Solomons,	W. H. Marsh,	....	"Have not appeared at Solomons."
Willows,	J. W. Talbot,	June 6	"I heard the first locust on yesterday and have neither seen or heard of any in my neighborhood except that."

TABLE II.—Continued.

Counties and Post offices.	Observers.	Date of Report.	Remarks of Observers.
CAROLINE.			
Denton,	J. W. Kerr,	June 4	"Locusts have not as yet shown up in Caroline."
Denton,	R. T. Carter,	June 4	"Have not heard of any locusts in our county."
Federalsburg,	C. S. Kauffman,	June 9	"Locusts have not made their appearance here as yet."
Goldsboro,	W. C. Cheffins,	May 28	No cicadas reported.
Goldsboro,	T. H. Coursey,	June 7	"I have not seen or heard of any seventeen year locusts in this vicinity this year."
Goldsboro,	Alex McKnett.	June 7	"Haven't seen or heard any locusts."
Greensboro,	W. E. Orrell,	July 25	"Have not seen or heard of any seventeen year locusts in our section."
Greensboro,	R. H. Jackson.	June 17	"The Periodical Cicada has not made its appearance in this section this year."
Greensboro.	G. L. Cohee,	June 10	"There are no seventeeen year locusts in this community that I know of."
Henderson,	W. L. Putchell,	June 4	"There are no locusts in this part of the state or Dela. that I know of,"
Henderson,	G. L. Cassarant,	June 6	"I have seen nothing to report."
Preston,	W. T. Kelly,	June 14	"I have not seen any locusts here this year nor in my life.I have lived here seventy years. 34 years ago they were in Talbot county, ten miles west of here."
Ridgely,	T. A. Smith,	June 6	"No locusts have as yet appeared in this section."
Two Johns,	C. Howard,	June 5	"We have not seen or heard any locusts in this neighberhood and hope we will not."
Williston,	A. G. Gelletley,	June 7	"I have not seen or heard anything of the seventeen-year locust."
Williston,	A. L. Quaintance,	Aug. 12	Saw five cast "skins" attached to a trunk of a maple tree.
CARROLL,			
Brummel,	J. M. Matthais,	May 29	"Locusts are very plenty in this community. They are mostly in the woods and where it has been cleared in the last few years."
Double Pipecreek,	J. P. Weybright,	June 9	"The seventeen-year locust is here in full blast, and very numerous."

TABLE II.—Continued.

Counties and Post offices.	Observers.	Date of Report	Remarks of Observers.
Finksburg,	F. L. Moore,	May 30	"The cicadas made their appearance here about the 23d inst. Up to this time they are much less numerous than in 1885."
Hampstead,	W. White,	June 13	"Locust's have been here since May 15."
Henryton,	T. Hennessy,	....	"Appeared about 1st of May. In full force about the 25th. Destruction clearly noticeable and great on young limbs."
Linwood,	S. W. Houtz.	June 2	"The periodical cicada appeared on the 23d of May in great numbers."
Linwood,	Jesse Smith,	June 10	"Locusts appeared here in some numbers May 20th and have not become very numerous in the forests."
Melrose,	C. H. Tracey,	June 4	"Locusts made their appearance about the 23d of May. Are now very numerous."
Mount Airy,	H. B. Wills,	June 15	"Locusts appeared in my locality May 18th and are very plentiful at this time."
Silver Run,	A. G. Humbert,	May 29	"First locust seen 24th of May."
Taneytown,	H. Miller,	....	"Appeared about May 20. Not many and damage little."
Union Bridge.	H. R. Fuss,	June 7	"Saw first Cicada May 19th. Old residents claim not so numerous as 17 years ago."
Westminster,	E. C. Bixler,	....	"Appeared May 15 in large numbers. No damage."
Westminster,	G. E. Stoner,	May 30	"First noticed cicada about the 20th. As yet there are not as many as one would expect."
Westminster,	W. Vanderford,	....	"Appeared May 21 in large numbers. Damage moderate."
Westminster.	G. H. Wolf,	....	"Observed latter part of April Large numbers along creek. Damaging fruit trees a good deal."
Westminster,	J. T. Yingling,	June 8	"Periodical cicada first seen May 21st. It is said by the oldest residents this is the largest brood in their memory."
CECIL.			
Cecilton,	G. G. Morgan,	May 30	"The cicada has not appeared here yet."

TABLE II.—Continued.

Counties and Post offices.	Observers.	Date of Report.	Remarks of Observers.
Chesapeake City,	Wm. Bloomer,	July 12	"Locusts first seen May 20th. Came very thick by June 1st, and disappeared June 20th. Sparrows eat most of them."
Colora,	Geo. Balderson,	July 12	"They first came up here in quantities May 23 and 24."
Colora,	G. G. Conner,	………	"Locusts appeared about May 20 in large numbers. I have noticed no serious damage to either trees or crops."
Elkton,	H. H. Gilpin,	May 30	"Seventeen year locusts are very numerous in this locality, particularly in the woods."
Elkton,	G. A. Thompson,	July 27	"Made their appearance here about May 22d. and damage was slight with us."
Fair Hill,	S. A. Mackie,	May 29	"They have not been seen in this locality but in small numbers."
Pleasant Hill,	— — ———	………	"A few appeared on the 15th of May. There has been a great many. Have not been destructive to crops as far as I can learn, but are in the young growth of trees."
Port Deposit,	I. Buck,	May 29	"Cicada first appeared about 20th inst. Are now quite numerous in this section."
Rising Sun,	J. R. Allen,	June 14	"Appeared about four weeks ago rather abundantly. The extent of destruction, if any, is not noticeable at this time."
Rising Sun,	E. H. Reynolds,	June 4	"We now have the seventeen-year locust in great numbers."
Rising Sun.	J. H. Maxwell,	May 30	"The locust is with us in the groves. A fair crop of them."
CHARLES.			
Bel Alton,	— — ———	………	"Have not appeared."
Doncaster,	— — ———	………	"Have not appeared here."
Doncaster,	A. B. Posey,	………	"No locust in this section. They were here in 1894 and will not appear until 2011."
Gallant Green,	W. C. Watson,	June 6	"I have not seen any seventeen year locusts here this year. Some of my neighbors have seen one or two. I heard one or two early this spring."

TABLE II.—Continued.

Counties and Post offices.	Observers.	Date of Report.	Remarks of Observers.
La Plata,	C Cromwell,	June 6	"The locust has not been seen or heard in our vicinity this year."
Nanjemoy,	Postmaster,	June 4	"No locusts here."
Riverside,	R. Marbury,	June 6	"I have not seen or heard of any locusts in this vicinity. Have made numerous inquiries "
Wayside,	T. Richmond,	June 5	"Have seen nothing of the 17-year locust in my neighborhood, nor have I met any one who has seen it."
White Plains,	... ...	....	"The locusts have not as yet made their appearance in Charles County. At least, I have not seen or heard of their presence."
DORCHESTER.			
Cambridge,	D. F. Kinnaman,	June 4	"I have not seen or heard any of the seventeen-year locusts in this locality."
Cambridge,	C. McIlvain,	June 10	"Not a single cicada has appeared here."
Cornersville,	Dr. S. A. Stokes,	June 5	"Have not seen or heard any seventeen year locusts in this section."
Cornersville,	L. M. Beckwith,	June 6	"Have not heard of the seventeen-year locust appearing in this county this year."
Gluckheim,	R. L. Gulick,	June 5	"There have been no periodical cicadas seen here. Have not heard of any in this vicinity."
Hurlock,	W. L. Harford,	June 6	"I have not seen or heard of any seventeen year locusts in my vicinity this year."
Hurlock,	J. E. Hubbard,	June 12	"Have not seen or heard any locusts in this vicinity."
Secretary,	C. E. Seidler,	June 6	"In our vicinity, I have not heard of any of the periodical cicadas "
Taylors Island,	W. C. Travers,	June 23	"Up to date I have failed to see one and have seen no one who has with the exception of one man who says he dug some out of the ground in his garden in early spring."
Vienna,	J. W. T. Webb,	June 3	"Have not seen or heard any of the seventeen year locusts in our neighborhood."
FREDERICK.			
Adamstown,	R. C. Suterers,	....	"Appeared about May 20. No damage."

TABLE II.—Continued.

Counties and Post offices	Observers.	Date of Report.	Remarks of Observers.
Araby,	Miss E. Baker.	June 2	"The periodical cicada plentiful. Not in great numbers. Came first 18th of May."
Brunswick,	C. M. Weems,	May 28	"They are here in plenty."
Buckeystown,	F. T. Bacon,	....	"Appeared about the middle of May, in large numbers. Not destructive."
Buckeystown,	J. H. Smith,	....	"Appeared in abundance in woods about a month ago. Not much damage was done to trees and none to crops."
Buckeystown,	C. F. Thomas,	May 31	"Locusts appeared here about the 23d inst. They are in great numbers in the woods. Very few around the village."
Ellerton,	C. F. Cartee,	May 30	"Seventeen-year locust made its appearance about May 22d. Hundreds coming up at a single tree"
Emmittsburg,	C. F. Rowe,	May 29	"Locusts made their appearance about the 10th of May. Very numerous in wooded parts of County."
Frederick,	J. A. Ramsburg,	May 25	"Have not seen more than two live ones so far."
Frederick,	E. Y. Goldsboro,	May 20	"Cicada appeared in small numbers in this locality. Most of them have been destroyed by English sparrows."
Graceham,	H. A. Meller,	....	"Appeared about the 19th of May and is very numerous. Little destruction is noticeable."
Hansomville,	J. W. L. Miller,	May 30	"Locusts are numerous with us this season."
Johnsville,	D. M. Devilbiss,	May 30	"Locusts appeared in large quantity last week."
Ladiesburg,	P. D. Koontz,	June 2	"They made their appearance here about two weeks ago. Are now in countless numbers."
LeGore,	Peyton Brown,	June 16	"Locusts appeared here about 15th of May and have done lots of damage to young fruit trees."
Lime Kiln,	H. G. Connor,	May 29	"We have a great many locusts along the mountains."
Middletown,	G. W. Main,	May 30	"They made their appearance here in large numbers. The first I saw was the 15th inst."
Middletown,	G. W. Main,	July 7	Reported as abundant.

TABLE II —Continued.

Counties and Post offices.	Observers.	Date of Report.	Remarks of Observers.
Monrovia.	W. L. Purdum,	....	"Appeared on May 17 and in great numbers. Have damaged trees but no crops."
Monrovia,	S. S. Day,	June 2	"Appeared here about the 15th of May. Seem to be in small quantities compared with 17 years ago."
Myersville,	C. U. Grossnickle,	June 2	"The locusts first made their appearance in May. They seem to be very numerous in the woods."
Myersville,	E. D. Palmer,	July 1	Reports cicada as feeding.
New Market,	S. M. Brussel,	June 9	"The seventeen-year locust is here in considerable force, but not so numerous as the last time (1885)."
New Market,	H. H. Hopkins,	....	"First seen May 8. Numerous only in circumscribed localities. Twigs of trees suffered to some extent where eggs were deposited."
New Midway,	F. C. Renner,	May 31	"Locusts are here in full. First appeared Friday, the 23d inst."
Rocky Ridge,	J. W. Late,	....	"Appeared May 15th in great numbers. Have done damage to peach, apple, chestnut and locust trees."
Rocky Ridge,	S. Valentine,	June 3	"We have plenty of locusts here. Saw the first ones about May 17."
Thurmont,	F. J. H. Rouzer,	....	"Appeared about May 10. Not destructive to a great extent."
Thurmont,	L. Sigmund,	May 20	"They have appeared in the mountains in large numbers."
Walkersville,	C. A. Nicodemus,	May 30	"The seventeen-year locust has put in its appearance in this locality. First seen about May 18."
GARRETT.			
Accident,	H. R. DeWitt,	June 3	"Have not seen or heard of the cicada. Have not heard of any in our vicinity."
Altamont.	T. Sollers,	June 2	"Have seen only two in this vicinity and heard but very few. Was at Blaine, 5 miles east of here Saturday and saw hundreds of them down there."
Bittinger,	E. E. Ellithorp,	....	"Appeared June 8th. They are scarce and did no damage."

TABLE II.—Continued.

Counties and Post offices.	Observers.	Date of Report.	Remarks of Observers.
Greelin,	D. L. Conneway,	June 2	"There have not been any locusts in this part of the state. '
Friendsville.	J. A. Dixon,	May 31	"The cicada has not yet appeared this season. They were here in 1897 and 1890."
Gortner,	H. W. Miller,	June 2	"I have not seen or heard of the cicada in this vicinity this year."
Grantsville	A. M. Stanton,	June 21	"The seventeen-year locust made its appearance here in some numbers about ten days ago."
Hoyes,	G. E. Bishoff,	....	"No locusts have appeared."
Mt. Lake Park,	D. H. Riley	June 21	"Locusts have been seen and heard in this vicinity, but were very scarce."
Oakland,	P. P. Lohr,	....	"Very few locusts appeared about first of June but did no damage."
Oakland,	J. H. Smithman,	June 2	"Up to date there hasn't been a locust within ten miles of Oakland this year, but last year they were thick."
Swanton,	O. W. Boyer,	....	"Locusts appeared about the first of June and are in great numbers in some localities in Swanton District, but no damage has resulted."
Swanton,	C. T. Sweet,	May 23	"I heard two or three on the 17th and an occasional one since."
HARFORD.			
Aberdeen,	I. H. Kernedy,	May 30	"Cicada appeared about 10th scatteringly. In my grounds they are abundant and the din of their vibration is ceaseless, excepting in the morning and evening."
Aberdeen,	I. H. Kennedy,	June 9	"The numbers of cicada have not increased."
Bynum,	W. P. Hoopes,	May 30	"Periodical cicada found first on 18th inst. They are not coming out in great numbers."
Bel Air,	J. H. Reckords,	May 29	"Locusts appeared in great numbers about three weeks ago."
Benson,	W. L. Amoss,	June 2	"The cicada has been here in small numbers for about ten days. In spots from one to seven miles from here, they are very numerous."

TABLE II.—Continued.

Counties and Post offices.	Observers.	Date of Report.	Remarks of Observers.
Cresswell,	Dr. O. B. Finney,	June 2	"Cicadas appeared in this neighborhood about May 24th. Now there are millions of them. I think they are useful and would be glad if they would come every year. They furnish food for cats and dogs and all the fowls."
Deer Creek.	G. E. Wilmer.	May 30	"Periodical cicada appeared in this locality May 23d Not in very large numbers and has not increased very much."
Fallston,	I. N. Moore,	June 2	"The seventeen year locusts are in certain localities in great abundance."
Flintsville,	C. J. Hamilton,	....	"Appeared in great numbers May 15th and trees are being damaged."
Forest Hill,	— — ——	....	"Locusts appeared May 21st. Not so many and little damage"
Glenville,	G. P. Cook,	July 9	"Locusts appeared here on the 23d of May. They were in large numbers and the damage done is slight."
Harford Furnace;	C. Dochey,	Aug. 6	"Locusts appeared in this locality May 18th. Song was first heard May 19th and entirely ceased by June 18th"
Harford Furnace,	T. Tobin,	July 4	"The seventeen year locust was in this section in large numbers about April 15th."
Joppa,	L.E. Hollingswo'h	June 30	"The periodical cicada appeared May 15th and by the 25th were in great numbers."
Pylesville,	S. W. Wilson,	June 10	"I think the locusts are, if anything, more plentiful than they were last time. They appeared about May 15th."
Stepney,	C. C. Slee,	May 29	"Locusts appeared in large numbers in some places and confined principally in the woods."
Street,	W. J. Thompson,	....	"Appeared 15th to 20th of May in great numbers and are doing a large amount of damage to the young trees of chestnut, peach and apple."
Street,	J. W. Galbreath,	....	"Appeared first part of May and have increased largely. Attacked some trees and did damage but not to fruit."

TABLE II.—Continued.

Counties and Post offices.	Observers.	Date of Report	Remarks of Observers.
Whiteford,	J. McCurdy,	....	"Appeared last part of May. Have done no damage thus far."
Wilna,	A. B. Hollingsw'h,	May 31	"This is the fourth locust year I have seen, By the 25th of May, they were as plentiful as I have ever seen them here."
HOWARD.			
Annapolis Junction,	W. S. Powell,	May 29	"The seventeen year locusts appeared here about the middle of May. Are most numerous in the woods."
Atholton,	C. H. Carr,	May 28	"Locusts have made their appearance in quite large numbers and are still coming up. In some of the old apple orchards the ground is like a honey comb."
Clarksville,	J. B. Zepp,	....	"Appeared about 1st of May in abundance. Killed twigs on all trees, although in orchards where chickens are they have not suffered so much."
Columbia,	S. S. Owing,	May 30	"Locusts made their appearance on my farm about two weeks ago, and are now very plentiful."
Fulton,	... ...	....	"Appeared about middle of May. Destructive to young peach trees and young branches on older trees."
Glennwood,	W. Hatbers,	May 30	"The cicada are here in large numbers and increasing daily."
Jessup,	C. G. Summers,	....	"Appeared about middle of May and in large numbers June 1st to 5th. Damaged ends of tree branches in some places, but generally very little was done."
Lawyer's Hill,	F. C. Kienke,	June 1	"The cicadas have started serious damage to young trees"
Lisbon,	N. R. Henderson,	June 30	"The seventeen year locust was in evidence in our locality."
Long Corner,	J. W. Penn,	June 2	"The periodical cicada has appeared in medium numbers."
Triadelphia,	J. T. Dardt,	June 29	"They appeared here on the 20th and 22d of May in very large numbers."

TABLE II.—Continued.

Counties and Post offices.	Observers.	Date of Report.	Remarks of Observers.
Woodstock,	A. M. Bensinger,	....	"Appeared about May 1st. Have attacked sassafras trees to a considerable extent and have done injury to them."
KENT.			
Betterton,	R. T. Turner, Jr.	June 4	"The locusts have been with us for about two weeks. They have been singing for several days."
Betterton,	F. Young,	June 4	"The seventeen year locusts were heard here on my place June 1st. Not very thick yet."
Chestertown,	W. T Brown,	June 6	":I have seen no locusts and have heard of a very few in this county."
Chestertown,	W. Eliason,	July 4	"In this immediate vicinity I have seen 18 or 20 shells and one locust."
Chestertown,	A. A. Harris,	June 5	"So far as I know the cicada has not appeared in Kent or Queen Anne counties. I have inquired in this locality."
Coleman,	J. S. Harris,	June 5	"The seventeen year locusts have appeared in this locality, but as yet in small numbers "
Fairlee,	A. M. Kendall,	....	"Appeared about the middle of May, but very few. Have not done any harm,"
Lankford,	W. T. Price,	June 5	"The locust has not appeared in our neighborhood as yet."
Lynch's	C. P. Norris,	June 4	"The locusts are here in great numbers."
Millington,	G. L. Turner,	June 7	"There has been no appearance of the locust this county to my knowledge this season."
Pomona,	W. R. Starke,	June 16	"They have not made their appearance in our locality as yet."
Rock Hall,	R. Wickes,	June 4	"We have no locusts so far."
Still Pond,	F. H. Harper,	....	"Have not seen a locust this year. I heard them in a woods about a mile away. This is the third appearance I have known but much less than either of the former. Have heard of no damage they have done. The first to my knowledge was about the 30th of May."

TABLE II.—Continued.

Counties and Post offices.	Observers.	Date of Report	Remarks of Observers.
Still Pond,	T. Raisin,	June 19	"Cicada made their appearance in Kent County about the 25th of May."
Tolchester,	G. E. Noland,	June 5	"First saw locusts two days ago. About a half dozen were on the wharf. Have appeared in considerable numbers six miles below here."
MONTGOMERY.			
Ashton,	F. S. Nowden,	....	"Appeared in great numbers May 25th. Destructive to chestnut but not to fruit."
Brighton,	A. Stabler,	May 30	"The cicada began to emerge on the night of May 15th. Were very numerous at first but cool weather with high winds have brought most of them to the ground."
Barnesville,	C. C. Mainhart,	Aug. 9	"Locusts appeared here about the 6th of May."
Cloppers.	J. D. Stang,	June 3	"Locusts have been here since the 20th of May. Are very plentiful now and still coming out."
Comus,	W. A. Maxwell,	May 28	"Locusts appeared about May 20th in rather large numbers, especially in woodlands."
Damascus,	J. W. Burdett,	May	"The seventeen-year locust has appeared in large numbers."
Germantown,	Miss H. Snyder,	June 2	"Locusts appeared here May 20th and are still coming out in countless numbers, swarming over every tree and shrub."
Glen,	R. C. Creamer,	June 5	"Locusts first made their appearance about 18th of May and to this time are in large numbers."
King's Valley,	J. R. Lewis,	June 5	"Cicada has appeared in this vicinity in large quantities."
Laytonsville,	S. Warfield,	May 31	"I saw the locusts the 12th of May. There are a great many more this year than last locust year."
Oakdale,	M. Kron,	May 30	"Locusts appeared here about two weeks ago."
Poolesville,	H. J. White,	June 5	"Cicada has appeared here in great numbers, coming out May 17th."
Sandyspring,	W. W. Moore,	June 28	"Cicada made its appearance about the 10th. On this place they were not nearly so numerous as in '85."

TABLE II.—Continued.

Counties and Post offices.	Observers.	Date of Report.	Remarks of Observers.
Sellman,	L. D. Mainhardt,	June 2	"The locusts are here in full force. Noticed first on the morning of the 19th of May."
Spencerville,	L. H. Duvall,	May 28	"Locusts are here and the first was seen about 10 days ago. I have seen four locust years. I think they get less every time."
Spencerville,	E.P.R. Margerum,	....	"Appeared in abundance May 25th. Destructive where no fowls are."
Wheaton,	R. G. Lamb,	May 28	"There are lots of locusts in this section and they seem to still come forth."
PRINCE GEORGE.			
Aquasco,	W. S. Chichester.	....	"Have not appeared at Aquas co."
Beltsville,	J. S. Dean,	June 2	"The locust is here in great numbers"
Clinton,	W.B.H.Blandford	May 28	"The seventeen-year locusts are not here in great numbers, but are in large numbers around Good Hope, Silver Hill, Forestville and Meadows."
Collington,	E. G. Beall,	....	"Locust seen on 18th of May and heard on the 21st. Not many. Young peach trees were being mostly injured."
Croom Station	... ...	....	"I have yet to hear or see any locusts."
Forestville,	E. E. Berry,	May 29	"Locusts made their appearance on the 18th of May. They are in large numbers in the woods around my farm."
Hardesty,	E. P. Gibbs,	June 1	"Locusts appeared in this section in small numbers on May 19th.
Lanham,	N. H Nicholson,	May 28	"Cicada has appeared here and is quite plentiful"
Leeland,	G. W. Brooks,	June 7	"Locusts made their appearance here in great numbers about the middle of May."
Mitchellville,	G. H. Thomas,	June 2	"Locusts have been here at least three weeks."
Muirkirk,	L. Brashear,	....	"Was observed in great numbers about June 1. Not destructive to crops and not much damage to fruit trees."
Ritchie,	J. B. Berry,	May 31	"The seventeen year locusts are very much in evidence in this vicinity. Appeared about two weeks ago but in

TABLE II.—Continued.

Counties and Post offices.	Observers.	Date of Report.	Remarks of Observers.
			less number than their last appearance."
Seat Pleasant,	J. E. Morrison,	June 20	"Locusts almost gone. Damage in this neighborhood slight."
Springfield,	C. G. Addison,	....	"Appeared in great numbers about middle of May. Injured only the new growth at extreme ends of trees. In fact they have been a benefit in my judgement. Birds and crows and poultry have fed on them, consequently no young corn was pulled up by crows. Hens have laid nearly double the number of eggs than usual, since the locust came."
Springfield,	C. D. Hopkins,	May 31	"Cicada appeared first on the 17th of May in large numbers, and have been increasing all the time."
Westwood,	F. Skinner,	....	"One or two have been heard, but none seen, as I have yet heard of."
Woodmore,	G. C. D. Townsend	June 21	"I first noticed them under tobacco bed canvas in very large quantities. They have injured apple, peach, chestnut and other small trees. Made first appearance during first week in May. Are now rapidly disappearing."
QUEEN ANNE.			
Barclay,	D. Wallace,	June 4	"We haven't any in this part of the country."
Carmichael,	J. H. Dodd,	June 16	"I have not heard but one seventeen-year locust. There have not been many in this locality since the year 1852."
Catlin,	H. H. Klinefelter,	June 4	"I have neither seen nor heard any in this locality, and on inquiry find every one of the same opinion."
Centreville,	W. T. Chambers,	May 30	"No seventeen-year locusts heard or seen in this locality."
Centreville,	Clayton Wright,	May 30	"No locusts seen or heard in this section of county."
Churchill,	James Brown,	June 5	"I have not seen or heard of any locusts in this or any part of the county."
Crumpton,	A. Clements,	June 13	"The seventeen year locust was here in small numbers the latter part of May. They

TABLE II.—Continued.

Counties and Post offices.	Observers.	Date of Report.	Remarks of Observers.
			were in very few localities and remained a very little while."
Queenstown,	C. S. Embert,	June 9	"The locust has not been in my vicinity."
Queenstown,	Daniel Friel,	....	"Have not seen, neither have I heard of the locust being in Queen Anne County. You are welcome to them Keep them in Baltimore County. They are evidently poor navigators. They get lost on the Chesapeake searching for the Eastern Shore."
Sudlersville,	A. E. Sudler,	June 10	"We have had no appearance of the cicada this year."
SAINT MARY.			
Budd's Creek,	P. O. Budd,	June 5	"Have not seen or heard of the seventeen year locust this year in this vicinity."
California,	C. Cole,	June 8	"I have not seen or heard of any seventeen-year locusts in this locality."
Compton,	W. S. Davis,	....	"No locusts have appeared at Compton."
Drumcliff,	A. J. Hayden,	June 12	"The locust has not made its appearance in this locality this year."
Great Mills,	H. Richard,	....	"Locusts have not appeared thus far."
Hollywood,	J. C. Wible,	....	"The seventeen year locust was here eight years ago. I have not seen a single locust."
Jarboeville,	W. Moore,	June 16	"I have not seen or heard of the locust in the county. They were here in 1894 in great quantities."
Leonardtown,	J. F. Duke,	June 5	"I have heard of no locusts in this county"
Leonardtown,	J. F. Morgan,	June 4	"The periodical cicada so far as I know has not appeared in this vicinity of the county."
Maddox,	T. H. Thomas,	June 21	"I have neither seen nor heard of any locusts in this section."
Pearson,	Dr. L. A. Hodgdon	June 11	"I have not seen but one locust here, which was dug out of the ground."
Valley Lee,	W. S. Coppage,	June 8	"In May, 1887, this fly was very numerous as well as destructive, and in 1894 they appeared also, but not so

TABLE II.—Continued.

Counties and Post offices.	Observers.	Date of Report.	Remarks of Observers
			numerous and almost exclusively in the forests. None has appeared this year so far."
SOMERSET.			
Costen,	J. W. Wilson,	June 6	"Have not seen or heard of any seventeen year locusts in this vicinity."
Manokin,	O. A. Johnson,	July 9	"In regard to the seventeen-year locust, don't think there are any in the county. We have made careful inquiry, and have not heard of any."
Manokin,	W. V. Maddox,	June 6	"Have not heard of locust in this neighborhood this spring."
Marion Station,	J. W. Hill,	June 6	"No locusts have been seen or heard of in this section."
Marion Station,	W. S Richardson,	June 10	"I have only heard of the seventeen year locust through the paper. Never saw or heard one."
Princess Anne,	R. W. Adams,	June 5	"The seventeen-year locusts have not appeared anywhere in this county that I know of."
Princess Anne,	H. F. Lankford,	June 7	"I have not seen any seventeen-year locusts this year. I have inquired of people living in different sections of the county, but have not found any one who has seen any this year."
Tull's Corner,	S. L. Tull & Co.,	June 5	"Have not seen or heard any attack of the locusts around here and hope we w'ont."
Upper Fairmount.	D. J. Maddox,	June 6	"So far as I know the seventeen-year locust has not been seen or heard in this vicinity this year."
TALBOT.			
Easton,	F. C. Goldsboro,	June 16	"No seventeen-year locusts have been seen in my neighborhood. I learn that they have been quite numerous between Easton and the Choptank river, along the river in forests. Appeared May 18th."
Fairbank,	J. V. Harrington,	June 16	"Have not seen or heard the seventeen year locust in this vicinity."
Longwoods,	F. Cape,	....	"Locusts appeared in Longwood's District about May 15th. Farmers report them

TABLE II —Continued.

Counties and Post offices.	Observers.	Date of Report.	Remarks of Observers.
			in considerable numbers. There is no appreciable damage done to trees or crops."
Matthews,	J. F. Saulsbury,	June 7	"We haven't any locusts in this section nor are there any on the Eastern Shore of Maryland as I know.''
Oxford,	L. H. Tull,	June 4	"I have not heard of any locusts in this section at all."
Royal Oak,	E. T. Benson,	....	"Have not seen or heard a locust this season. Don't appear to be in our neighborhood."
Royal Oak,	R. H. Meads,	June 11	"I have not heard of the presence of any locusts in this vicinity of the county.''
St. Michaels,	Jacob Crone,	June 4	"We have had no locusts on the farm. Have not heard of any in St. Michaels District."
Trappe,	W. Collins,	June 9	"Have not seen a single locust nor have I heard of one in this neighborhood."
Tunis Mills,	J. H. Bailey,	June 8	"The locusts have not made their appearance in this vicinity yet, but have been seen in large trees in the woods about five miles from here."
Valliant,	H. B. Valliant,	June 23	"There are no locusts in this locality. Quite a number at Pikesville.''
WASHINGTON,			
Beaver Creek,	D. J. Vitmer,	....	"Appeared in large numbers about May 10 and did some damage."
Big Pool,	S. Johnson of J,	June 17	"The locusts are now here in abundance and are doing destructive work on our fruit trees."
Big Spring,	M. Charles,	May 29	"About two weeks ago I heard the first locust. It is my belief that they are less than they were seventeen years ago.''
Boonsboro,	Shafer Brothers,	May 29	"The locust has made its appearance in large numbers."
Brownsville,	J. P. Blessing,	....	"They made their appearance in this section in squads from the 15th to the 25th of May. Mated the last of May and began depositing eggs the first week in June.''
Brownsville,	B. S. Burkitt,	June 2	"Locusts first seen between 10th and 15th of May in the

TABLE II—Continued.

Counties and Post offices.	Observers.	Date of report.	Remarks of Observers.
			mountain section. They are more abundant in the woods and newly cleared ground.''
Cavetown,	J. A Richardson.	May 28	"The locust appeared in this locality in immense numbers. On warm days you cannot hear any other sound but their song."
Clearspring,	W. W. Frantz,	....	"Appeared in large numbers May 9th and were very destructive.''
Cearfoss,	D. W. Kirshner,	May 30	"The periodical cicada has appeared in this vicinity in large numbers First noticed about the 18th of May."
Chewsville,	D. E. Oswald,	May 27	"The locusts have made their appearance in very great numbers. Orchards and fence rows are full."
College St. James,	G. Febry,	June 21	"The locusts are a thing of the past. I don't think they did any damage ''
Downsville,	Isaac Long,	May 29	"Locusts made their appearance here in great numbers on May 20th."
Eakles Mills,	N. Rohrer,	June 5	"First noticed about the 20th of May. Are now very abundant.''
Edgemont,	R. B. Brown,	June 2	"Locusts appeared about the 20th of May in some numbers. Are now very numerous."
Edgemont,	J. A. Nicodemus,	May 20	"Some locusts are here now, but I do not think so numerous as seventeen years ago.''
Fair Play,	W. W. Eakle,	June 3	"The locusts are here very plentiful in our locality. Noticed them first about the 15th of May.''
Gapland,	G. W. Kaetzel,	June 2	"The cicada has appeared in this locality throughout this county in numerous numbers."
Gapland,	T. R. Brown,	May 29	"The locusts are here in large numbers."
Green Spring,	J. R. Zimmerm'n,	May 29	"Saw first locust on 'Whit Monday'. The woods are now ringing with them."
Hancock,	E. P. Cohill,	May 28	"Made their first appearance about the 18th. By the 25th the forests were full of them. This cold snap seems to have killed many of them.''
Hancock,	E. D. Stotlemeyer,	....	"Appeared in large numbers about three weeks ago. Some

TABLE II.—Continued

Counties and post offices.	Observers.	Date of report	Remarks of Observers.
			damage has been done to young apple trees"
Indian Springs,	D. B. Holland,	June 2	"We have millions of the seventeen year locusts here and are still coming up out of the ground."
Keedysville,	E. A. Pry,	May 29	"Lots of locusts. More frequent along timber regions. Thousands of them."
Keedysville,	E. H. Hoffman,	May 30	"Cicadas appeared about May 2nd They are in considerable numbers in the mountains. They have been kept back by cold and windy weather."
Keedysville,	J. A. Miller,	....	"Appeared about May 15th in large numbers in forests. Chestnut orchards almost ruined. Also attacked fruit crop.
Keep Tryst,	James Smith,	May 29	"The locusts appeared here about ten days ago. They came in great numbers"
Mapleville,	C. S. Keller,	June 23	"The locust made its first appearance in abundance along the mountains, and are doing serious damage to trees"
Sharpsburg,	H. N. Miller,	May 28	"Cicadas are found in great numbers now in this locality."
Sharpsburg,	C. G. Biggs,	May 30	"The seventeen year locust began its appearance here in quantities about two weeks ago Considerably more in the mountains thus far than in the valley. They appear apparently in places, or restricted territory rather than general"
Sharpsburg,	S. S. Stouffer,	June 19	"Locusts appeared in large numbers May 19th and were practically gone by June 28."
Sharpsburg,	Frisby Smith,	July 10	"The first locust appeared May 19th. Occurred in immense numbers from May 23 to June 29. By June 25 nearly all had disappeared."
Smithsburg,	W B. Dayhoff,	May 26	"Locusts appeared May 22d in small numbers, but now the air is full of them."
West Beaver Creek,	A. B. Martin,	June 9	"The cicada is here in about the same numbers as in 1885, but perhaps confined to a more limited area."
Weverton,	C. E. Miller,	May 31	"Locusts are here by thous-

TABLE II.—Continued.

Counties and Post offices.	Observers.	Date of Report	Remarks of Observers.
			ands. Ground perforated with their holes. Sometimes 10 or 20 to the square foot."
Williamsport,	A. S. Johnson,	June 7	"Very few locusts have been seen up to this date. We first heard them May 20th."
Williamsport,	W. E. Cushen,	June 21	"In this vicinity there has been but few of them. They are reported not so numerous as seventeen years ago."
WICOMICO.			
Allen,	J. W. Jones,	June 9	"I have not seen or heard any locusts."
Athel,	S. J. Phillips,	June 26	"I have not seen or heard any seventeen-year locusts in my locality. I hear they have made their appearance just across the Delaware line."
Mardela Springs,	A. B. Armstrong,	June 5	"The periodical cicada has not been heard or seen in this vicinity this year."
Pittsville,	J. H. Truitt,	June 3	"The cicada has not made its appearance in this locality, and I have not heard of its appearance in any place in our county."
Salisbury,	R. M. Johnson,	June 5	"I fail to find any indication of the appearance of the seventeen year locust in this locality."
Salisbury,	W. F. Allen,	June 9	"As yet I have seen no seventeen year locusts. I trust not to make his acquaintance."
WORCESTER.			
Box Iron,	W. S Parson,	June 5	"Will say that the cicada has not to my knowledge made its appearance in this vicinity."
Corbin,	T. R. Corbin,	....	"Not a single specimen of the seventeen year locust has been seen or heard here nor within a radius of ten miles or more"
Ironshire,	R. C. Peters,	June 5	"I have seen nothing of the seventeen year locust so far nor heard of it being any where in our county
Snow Hill,	C. M. Peters,	June 7	"The seventeen year locusts have not made their appearance as yet in this locality"
Snow Hill,	J. S. Blackman,	June 14	"I have not seen or heard of any in this section."
Pocomoke,	W. Hall.	June 4	"I have not seen the cicada this year nor heard of its appearance in this vicinity."

SOME LETTERS FROM OBSERVERS.

A considerable number of letters were received, detailing observations on the cicada, some of which are presented as bearing on the occurrence of the insects in the respective sections of the State indicated. The observations are of particular interests on account of the dates given and the remarks on the relative abundance, and on the destructiveness of the species.

Garrett County; Chas. T. Sweet, Swanton, May 23, 1902;

"Regarding the 17 year "Locust" I heard two or three the 18th and occasionally one since. Am going to be in other neighborhoods in a day or two and will report later.

June 16th. They have been in the warmer sections of the County two or three weeks and mostly very numerous. They have not reached Swanton only very few at this date.

Aug. 11th. No locusts have been here to speak of. North of here 5 to 10 miles they have appeared in large numbers."

Washington County; A. B. Martin, West Beaver Creek, July 7, 1902;

"I find that the damage done by the Periodical Cicada is quite serious in the fruit belt on the South Mountain in the vicinity of the village of Smoketown, to which locality outside of the immediate vicinity in which I reside, my observations are confined.

The growing crop of peaches is very much damaged as well as the young trees, just set out, or from one to three years old. The injury to the former will not, it is thought, be permanent, but that in the case of the latter the damage done is more serious, since it is likely, it is claimed, that many of the trees will be stunted and that a stunted peach tree never amounts to much. This season's berry crop. that is the raspberry and blackberry was not injured. This year's growth of cane however was badly stung and may seriously effect next year's crop since it will break-off at the places pierced by the insect. Some of the young forest trees, notably the chestnut, were very much stung at or near the extremity of the smaller branches; whether or not the trees will be permanently injured cannot now, it is thought, be foreseen.

In this locality and other localities in the settlement the cicada was not very numerous and the injury to fruit trees, &c. was very slight, except where orchards had been planted near wooded lots and even then the damage wrought was or is slight compared with the mountain districts. As I wrote in the card to you, the difference in time of the first appearance of the cicada in the "settlement" and the mountain region, was quite marked, having been as much as a week or ten day's difference. So marked was the difference that at one time I thought that it would not appear in this immediate locality at all. In the time of its disappearance in the two localities, I noticed no appreciable difference."

Washington County; Chas. E. Koogle, Boonsboro, June 30, 1902;

"May 17th saw first winged forms. May 20th heard first song. Do not fly or sing much in cool weather. East and South exposures on hillsides where it is warmer they appear several days sooner. First ovipositing of any consequence noticed June 2nd.

Saw last in pupa stage June 9th. They are quite active from early morning till about 3 o'clock p. m. in warm weather. In afternoon and toward evening they collect on trunks of trees (in orchards) and have seen the trunk covered from ground well up on the large limbs, and have noticed that they feed, having their beaks on tree, (and I believe that much sap that now is oozing out on the trunks is due to their work.)

June 7th some few dying. June 10th many getting helpless and lying dead. Evidences of much damage appearing. June 16th many dead and principally males Most damage done in our orchard during week ending June 14th. Saw few depositing eggs June 28th and at this date there are yet live ones to be seen, but the cool rainy weather is weakening them. As to damage done by them, in orchards adjacent to timber, or on ground where there was timber seventeen years ago, the trees are badly used up, and in our own orchard we are cutting off practically all of last year's growth, and much of year before, that is injured; we have lost all our fruit and ours is only a sample of many others. In many young orchards (1 yr.) the trees are so injured that many will doubtless die unless the season is very favorable, and they have good attention.

In country orchards where they are away from timber, there is practically no damage. At this date, June 30th., there are as I have said, still a few cicada moving around and occasionally a song, but in a few days they will sing "Pharaoh" no more and there will be quiet in the land."

Washington County; Jno. Nicodemus, Edgemont, June 28, 1902:

"I write you to say the Locusts have been very destructive to our young apple orchards here at the Mountain, as well as to our nursery stock. Would you advise heading trees 4 year old back to unwounded wood, and would you advise cutting one year old apple stock off at the ground. The trees are badly stung and wounded in every shoot over the tops, mostly the size of a pen holder, as three-eighth inch shoots. My idea is to cut the nursery stock off at the ground, and form a new tree and to head back the 4 year old and 5 year old trees to form well balanced tops, taking off both wounded and unwounded shoots to form a balanced and symmetrical top. Is this right, or would you advise a different treatment of these mutilated trees? I wish you could see what havoc they have made of our beautiful apple trees. Near Winchester, Va., where I have 500 acres of apples, they have done us little damage. In Pennsylvania, where I have 150 acres of apples they have hurt it but very little. But here it is perfectly awful; at first when they came, I think I wrote you they were of little consequence. But they have since changed my opinion. Do not see how they could be much worse."

Frederick County; Geo. W. Main, Middletown, July 7, 1902.

"According to promise, I will now give you a history of the Seventeen year Locust according to my observation. I live two miles east of Boonsboro along the Turnpike. The first signs of the Locusts was about the eighth of May, when they opened the doors of their cells, and they then went back a little way and remained until the fifteenth of May; then the first Army made their appearance and the largest number came on the twenty fifth, and so on and up till as late as the first of July, a few more came yet. They did a great deal of damage to young Peach trees, they stung the limbs and the bodies thus killing entire orchards. Oak and Chestnut trees are also greatly damaged on both Frederick and Washington County sides of the Mountain; it looks as though a fire had passed over killing the limbs. I think the cold weather in June kept them from doing more damage as it caused great numbers to die, there is still a few singing yet. This is the damage done in Boonsboro District No. 6 and Jackson District No. 16."

Carroll County; Frances L. Moores, Finksburg, June 28, 1902.

"In this section, the periodical cicada began decreasing in numbers several days ago and have since entirely disappeared, except probably a few in the woods. As far as I can learn injuries from them are light in this immediate locality. The various fruit crops have been somewhat diminished. Nearly all the pierced twigs, from fruit trees, were those with fruit on them. In the forest, the oak appears to have suffered most.

The only noticeable peculiarities, of this, as compared to other periods, are their smaller numbers and their unequal distribution."

Carroll County; J. T. Yingling, Jr., Westminster, June 8, 1902;

"In the following I will give you some information on the occurrence of the present brood of the Periodical Cicada. They were first seen in this section on Wednesday morning, May 21, 1902. It is said by our oldest residents, it is the largest brood to their memory. They seem to make their appearance mostly in the evening or early part of the night. They are so numerous in some parts of Manchester district, that the fences, trees, grass, grain, etc., are covered with the pests. They noticed too of depositing their eggs as early as June 1, 1902, mostly in the forest trees. No damage done to the fruit trees in this section yet. (Up to the 8th). Some are dying, and others are still coming. The air is filled with their song "Pharaoh"."

Baltimore County; W. H. Evans, Chase, July 1, 1902:

"As per your request I write up what I noticed concerning the "Cicada" during his brief existence in our midst.

To begin with I first noticed them coming out of the ground and sluffing May 20th. They began flying around June 6 but not very numerous. They made considerable noise for the few to be seen and with the Birds, Turkeys, Chickens and Bumblebees pursuing devouring and killing the "Cicada," they had a very poor chance to do any damage. The Bumblebee feature may interest you as being a parasite for the "Cicada." I was walking along the road one day and a Locust with a bee attached to him—like a bulldog—fell at my feet. I stooped and picked them up to see what sort of a thing it was. The Locust was dead and the bee was savagely boring him to make sure work of it. I tried to separate them but the old fellow made such a fuss I concluded to let him alone. Since the 25th I have not noticed any of them nor heard them. They were not ver y numerous at Chase and did but very little damage and that was confined to the low shrubbery and bushes; here and there you can see a dead twig but not enough to talk about. They appear to have come in spots or sections and to have remained there. At Benjies Satation, 2 miles from here, they were quite numerous and their works are more in evidence. We were all badly scared but it now appears without a shadow of foundation."

Harford County; Dr. O. B. Finney, Creswell, June 3, 1902;

I saw in my County paper "The Bel Air Times" of your request for the occurrence of the Cicada. They were heard in this neighborhood first, about May 24th, 1902. Just now there are millions of them; and I think they are useful. It would be well if they would come every year. They furnish food for cats, dogs, and all the Fowls. The Poultry eat them so freely, they refuse other food when it is given them. The only harm they do is to kill some of the limbs on young fruit trees, but I notice there are limbs enough left on the trees. Some of the papers say they are good for persons to eat. I doubt it. In the famine districts of India, they might be a God-send, but not in America. They like the warm sunshine, then they are most noisy. Evenings or a shower stops them immediately. The ground hereabouts is bored full of holes where they come up. I think that it is good to let the rains in to filter through the ground for the crops."

Harford County; W. P. Hoopes, Bynum, June, 28, 1902.

"You asked me as to the Periodical Cicada, and I answered as to their appearance. I found the first ones out on May 19th, on a bushy south hill; found the first incisions for eggs made on the 1st of June and I have not seen or heard any since June 23d.

They have done considerable damage to small bushes and fruit trees, especially; on our apples set in '01 many of the trees have had most or all of the limbs and sometimes even the trunks punctured and the strong wind has since broken many of the limbs off. For about two days they were very plentiful on an orchard which had been bare of trees for years, and where no locusts came out of the ground; after that they seemed not to bother it. As to the comparative damage done, I cannot say, as I do not remember just what they did in '85."

Cecil County; Geo. Balderston, Colora, July 12, 1902.

"In reference to the Locusts now that they have gone. They first came up here in any quantity on the evenings of May 23rd, and 24th, the most of them on the evening of May 24th, between 7 and 9 o'clock. Heard no note from them for about 3 days, later and after that a continuous hum in the woods and large trees. Noticed the first ovipositing on the 6th of June. They have not been severe on our fruit or shade trees, and no material damage has been done anywhere. There is an abundance of dead twigs on the *outer limbs* of fruit trees and along the roads or fence rows where trees have been standing for years. The brood seemed to have gone entirely by the 20 of June.

If no more destructive than this season no warning in regard to fruit trees need be given unless it be not to plant on land contiguous to forest trees that harbor the Cicadas."

Cecil County; Geo. H. Thompson, Elkton, July 27, 1902.

"I see by your Bulletin No. 37, March 1902, where you desire to know something in regard to the Periodical Cicada in different localities. They first made their appearance here about May 22, and their damage with us was light; some 3 year old Quince tree near the woods were stung and 3 or 5 were entirely destroyed. Apples and pears were not disturbed. and 50 peach trees set out last spring 1902 were also not disturbed by the Cicada. The forest seems to suffer most as it is almost brown in some places, and their period of duration was of about 4 to 5 weeks, As the spring was cold, I suppose it helped to shorten their days of destruction. Their number was not very large with us, but there was enough to feed the crows and other birds, so that not a hill of corn was taken by them last spring with us, and you could hardly see or hear a crow while the locust existed. Some reports of the locust killing young chicks by getting in the crop and not digesting, but I think they must have been mistaken as none with us happened that way; they seem to relish and thrive on them. I also saw a few of the cicadas last summer."

Kent County; Thos. Raisin, Still Pond, June 19, 1902;

The cicadas made their appearance in Kent on or about the 25th of May, and in some localities they were in very great numbers The woods all along Howels-point farm belonging to Mr. James G. Harris was full of the locust, one for every leaf on the trees, yet they did but very little damage either to forest or fruit trees, owing I think, to the cold weather, just at the time for them to put in their destructive work. I went out early one of those cold mornings and found the locusts on the trees so cold they were unable to move. Gave the trees a shake and they fell to the ground and there the most of them perished. They did however slight damage to Mr. Harris' Peach orchard, killing the tops of about three or four hundred trees just a few yards out from the edge of the woods. The woodland along Lloyds creek was infested with locusts in great numbers and as far as I can learn where ever there is heavy timber the locusts were more or less in numbers to be found, but the damage sustained has been so slight that one hears no talk of the locust. Therefore I conclude but little injury has been done anywhere in Kent County. These pests began to disappear long about the fifteenth of this month, not one to be heard any where at this date "

SUMMARY AS TO THE DISTRIBUTION OF THE PERIODICAL CICADA IN MARYLAND IN 1902.

The distribution of brood X of the cicada is shown in the map to which attention has already been called. It will be noted that throughout the northern and western part of the State generally, the insect was quite abundant. The southern limit of the brood, in any considerable abundance, is, in Southern Maryland, in the vicinity of Upper Marlboro, in Prince George's County, and along a curved line to the neighborhood of Annapolis. There are numerous localities south of this imaginary line, where its occurrence was reported in small quantities, or on somewhat questionable evidence. In this territory this brood is probably to be regarded as on the verge of extinction, and its entire disappearance will likely follow in a few generations. The record of the cicada at Mutual, in Calvert County, the most southernly reported locality of this brood in the State, is possibly open to question, as the correspondent stated that he "Had'nt seen any locusts, but have heard one on May 12th."

On the Eastern Shore, the insects were reported as locally abundant as far south as Lynchs Station in Kent County, with the addition of two or three rather separated localities in Talbot County, where, owing to the preservation of certain timbered areas, the insects have held their own. As shown in the chart, the insects are here quite isolated from the thickly infested territory to the north, their most southern occurrence being practically bounded by the Chester River. In the extreme western part of the State in a portion of Garrett County, this brood was reported as entirely absent, although occurring in considerable numbers, along its eastern boundary.

In many localities throughout the general range of greatest abundance of the cicada, the insects were reported as comparatively scarce. As has been stated, the adults do not fly far from the vicinity of their emergence and are thus confined largely to the forests, patches of woods, or old orchards, where the larvae lived beneath the soil. Considerable areas of farm lands, that have been cleared for many years, may thus be largely free from the insects, though located in the centre of the general area of infestation. Several correspondents have made reports, which indicate this condition. A review also of the remarks of observers, plainly indicates that in many localities, particularly along the more southern limit of the brood, the insects were notably less abundant this year, than during the time of their last appearance, in 1885.

THE EXTENT OF INJURY.

It would be difficult to even approximately express the amount of damage occasioned by the cicada, during its recent visitation. Excluding for the moment, the injury done to forest trees, and confining remarks entirely to fruit trees and shrubs, it will be observed in many cases the damage cannot be properly reckoned at this time, since the injury received, must injuriously effect the plants throughout their future existence and may be directly or indirectly responsible for their premature death. The effect of the punctures on fruit trees may be to cause a weakness of the future branches to such an extent that these will be broken off by high winds or heavy fruit crops to the considerable injury of the tree. Or the wounds may never properly heal over, so that the vital parts will be exposed to the various agencies of decay and to the extrance of wood boring insects.

One feature of the damage caused by the insect is the loss in some sections, of the current fruit crop. Pronounced damage of this character has been confined largely to mountain orchards, or those similarly situated, with respect to forests. Where the insects were very abundant, the one and two year old peach and apple wood, was quite killed from excessive oviposition by the females.

Numerous orchardists gave their injured trees a severe pruning as soon as the cicada had disappeared thus forcing out a new growth the present season. Aside from the permanent injury which the trees may have received in the way of wounds, they have doubtless been much benefitted by the pruning, which should serve to offset in a measure, the loss of the present year's fruit crop.

The seriousness of injury to fruit trees has been commented on by numerous observers, both in the published letters and in Table II, which may perhaps be considered typical for the respective localities given. Several young orchards, along the Blue Ridge Mountains, which the writer was called on to visit, were indeed literally "cut to pieces," and only the most severe pruning could reasonably bring them out of the difficulty.

Fortunately, comparatively few fruit trees were planted in the Mountain sections during the past fall and spring, on account of the predicted occurrence of the insects, and considerable loss has thus been avoided. The excessive injury to two and even three year old orchards, would seem to warrant the advice that young trees, near large original forests, should not be planted during the two or three years preceding a cicada year.

The injury to forest trees, which receive by far the greater part of the eggs of the cicada, while very marked in the dead twigs and brown leaves, is not of a serious character. The females, in their egg laying are confined largely to the one year wood, and hence only terminal parts of the branches are injured. Aside from a general pruning effect, and the more or less complete loss of one year's growth, the damage is inconsequential,

REMEDIAL AND PREVENTIVE MEASURES.

Considerable attention should be given to injured trees during the coming winter and spring, if they have not already been looked after. All badly punctured twigs and limbs up to the size of one's finger, should be pruned off, and allow new shoots to form. As much as possible, the symmetry of the tree should be preserved, but in any event, the removal of seriously injured twigs of the size indicated is advisable. This will be a good time to give the trees a thorough over-hauling, and if the injured and unproductive wood is carefully removed, a much improved condition of the orchard will be the result. The complete recovery of the orchard would be greatly insured by thorough fertilization and cultivation during the following spring and summer.

In the case of injured apple trees, attention should be directed to the control of the wooly aphis, which has a tendency to colonize in the wounds left by the cicada. The injured places are thus prevented from proper healing, and the drain of the aphids on the plant's vitality,is in itself considerable. Spraying the trees with Kerosene emulsion, whale oil soap or other insecticides of this class should keep the insects under control. Painting the wounds occasionally with a thick solution of whale oil soap would doubtless accomplish the same results. Trees should be examined for several successive winters, and branches bearing scars, which fail to heal, should be thoroughly treated with the whale oil soap solution or removed entirely, where this will not seriously affect the tree.

As has been stated in the early pages of this bulletin, the principal injury occasioned by the cicada is that done by the females in egg laying, the presence of the larvae or pupae on the roots of trees not being of sufficient importance as to require attention. The extent of injury by the adults in a given locality, will be in proportion to their abundance at that place. The map showing the distribution and relative abundance of the insects, as well as the data in Table II should form a basis for an approximate estimate of the abundance and consequent injury likely to result from their next appearance. It should also be remembered that on the whole the broods are becoming numerically less and less with each occurrence. Over the Eastern Shore, south of northern Kent County, the cicada may be quite disregarded, in its relations to the orchardists, except possibly in the localities indicated in Talbot County. Also in Southern Maryland and south of central Anne Arundel and Prince George Counties, this brood of the cicada can have practically no economic importance. Throughout the more northern and western part of the State, the cicada may be expected in great numbers, and during the two or three years previons to the scheduled dates of their appearance, the planting of trees, particularly near forests, and on recently cleared land, should not be done.

The destruction of the adults after their appearance, if in large numbers, is scarcely feasible. In a small way, the insects could be destroyed with strong kerosene emulsion, with Pyrethrum powder, strong whale oil soap and probably other insecticides that kill by their corrosive or suffocating effect on the insect.

To be successful, such work should be directed against the cicada very soon after they have shed their pupal skins, and while they are yet very delicate and helpless. Operations should be begun with the first appearing insects, and continued on successive days until they have largely left the soil. Early each morning of this period, would offer the best opportunity for the work, as at this time the individuals which appeared during the preceding night, would still be comparatively helpless and low down on the bushes or lower limbs of trees. It is quite practicable to protect valued shrubs or low trees by keeping them covered with thin cloth during the prevalence of the insects, and this method has been used to a limited extent in the state the present year.

The larvae and pupae may be destroyed to a certain extent by injecting carbon bisulphide into the infested soil, much as is done in the control of the *Phylloxera* in some parts of Europe, and in this country to a much more limited extent in destroying insects infesting the underground portions of plants generally.

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ECONOMICAL METHODS FOR IMPROVING THE KEEPING QUALITIES OF MILK.

BY CHARLES F. DOANE.

Most of the dairy farmers of Maryland are engaged in producing milk for consumption as milk rather than for the making of butter or cheese. This is but a natural condition due to the location of one large and wealthy city (Baltimore) within the state and with Washington and Philadelphia on the borders; all of which offer good markets for milk. Under usual conditions the sale of milk for consumption is found more profitable than the making of butter and it also generally entails less labor.

Notwithstanding the fact that the farmers in most parts of the State are favorably located for the sale of milk there is also in the districts more removed from the cities a large interest concerned in the making of butter both on the farm and in connection with creameries. The matter of keeping milk in good condition for a considerable length of time is of paramount importance to the shipper of milk for city supplies and it really is of equal importance to the patrons of creameries or butter and cheese factories from the fact that precautions which contribute towards improving the keeping qualities of milk will also contribute towards improving the quality of butter and cheese.

Again, the subject of this bulletin is one that not only concerns the producer but also the city dealer and the consumer of each have their part to perform in order that the best results may be obtained.

Neither the city consumer nor the creamery can make use of spoiled milk, and the easiest and most economical way to keep it from spoiling should interest any person who handles milk in any capacity.

The question which confronts the milk producer of Maryland and of the entire south are grievous ones with which northern farmers are not and cannot be acquainted. This applies particularly to the dairymen living south of the latitude of Baltimore, but, in a measure, would apply also to practically all of Maryland lying east of the mountains. In this region there are few springs, while wells in many cases do not furnish water cooler than sixty degrees. This, together with the uncertainty of the ice supply, causes no surprise that preservatives find such a ready market in the Baltimore dairies.

But notwithstanding all these discouragements it has been demonstrated conclusively by the work done at this and other stations, the results of which are given in the following pages, that it is entirely practicable to furnish milk in the streets of Baltimore and Washington in as good condition as when it is first milked. It will require a few minor changes on the part of most individual milk producers, but these changes need not entail any particular hardship in caring for the milk, and in most cases but very little extra expense. In fact in many cases the expense might be decreased, especially as regards the item of ice. Not that it is considered that ice is not desirable, but such large quantities need not be used as are used now.

To gain this end the producer must make a little more rational use of the means which nature has provided him with. The actual knowledge of the majority of dairymen reduces itself to rather simple principles. They know that milk sours more quickly in warm than in cold weather, and, therefore, that milk will keep better when cold than warm. But the actual degree of temperature required to keep milk in good condition for any desired length of time, is a matter of conjecture on the part of both shipper and retailer; and the desirability of cooling the milk as soon as it is drawn from the cow seems to be unrecognized by even the best of dairymen. It is also true that the need of any practical method to promote cleanliness is not recognized by either producer or retailer. In fact, it may be considered that the retailer may be more at fault as regards this last point than the producer. It is a business where everybody concerned needs to hunt around for a few new ideas.

WHAT MAKES MILK TURN SOUR.

To understand fully the reason for milk turning sour one must leave that which would be recognized as entirely simple and indulge in a little scientific explanation. Fortunately all organic matter, or what might better be termed vegetable and animal products, commence to decay, or as is sometimes termed ferment, as soon as or shortly after they are brought into contact with the air at normal temperatures. Were this not so, it would not take many years for the earth to be entirely encumbered with the dead and useless bodies of plants and animals. This decaying or fermenting is caused by bacteria, which themselves are very small vegetables, but from their ability to increase in numbers very fast it is possible for them to play an important part in a great many things which affect the human race. It is these small vegetables, or bacteria, which cause milk to turn sour. They get into the milk in various ways, which will be mentioned later, and if the conditions of temperature are right they multiply rapidly and turn the sugar found in all milk into an acid which gives the milk its sour taste and which eventually curdles or thickens it. It being the case that these small vegetables are responsible for the changes in the milk, it is perfectly plain that if they could be excluded from the milk, or if the conditions of the milk could be made such as to keep them from growing after they get into it, the problem would be solved. It should also be plain to the reader that the smaller the number which get into the milk in the first place, the longer the milk will remain in a condition fit for consumption.

To keep the bacteria out of the milk is entirely impossible, though there are many little things which if observed will materially reduce the number in the fresh milk. To give in detail a few of these which it will be entirely practical for the ordinary milk producer to observe, and to explain the best and cheapest way to prevent these germs from growing so fast, will be the object of the following pages.

Bacteria get into the milk in a number of ways, which are as follows:

1. From the udder of the cow.
2. From dirty cows and milkers.
3. From dusty air.
4. From dirty buckets, strainers and cans.

Nearly all of these contaminating sources can be regulated, to a certain extent, without expense and with very little extra work. They will be taken up in detail.

The inside of the udder of the cow is never free from bacteria. The greater part of the germs found in the udder are in the foremilk, or the milk contained in the teat and which is drawn off in the first two or three streams from each quarter of the udder. It was supposed for many years that the upper part of the cow's udder was entirely free from bacteria, but this has been demonstrated to be a mistake by A. R. Ward (Cornell Station, Bulletin No. 178), who examined the upper part of the udder of a number of cows and found them to contain bacteria in every instance. A number of other well-known investigators had previously stated in published reports that the upper part of the udder contained no bacteria when the udder was in a healthy condition, but, as the work of Ward was more accurate and was practically verified by Moore, with whom he was associated, his results would come very near being considered as conclusive. It is true that the bacteria found in the upper part of the udder were not injurious to the milk, but it simply illustrates the futility of attempting to secure milk entirely free from contamination of some sort.

As the foremilk contains the greater part of the bacteria, these can be excluded from the bucket by milking the first two or three streams from each teat onto the ground or floor, or into a little can provided for the purpose. This practice would cause but very little if any loss, for this first milk is very poor in quality. With the milk shipper the weight would be lost, but it would be better for the general quality of the milk if the foremilk was thrown away.

There are two or three reasons why an effort should be made to keep cows clean. As many cows are ordinarily kept in winter, the flanks and hind quarters of the animal become plastered over an inch deep with dried manure. It is very easy to see how utterly impossible it is to keep the milk clean when the cows are so dirty. Some of the dirt cannot be prevented from falling into the bucket. To keep from being downright filthy it is necessary to take some measures to keep this manure from getting into the milk. Many a person who would not drink water into which a particle of manure had fallen will drink milk that has an over-abundance of it; and of course these people would not hesitate a minute to sell such milk for others to consume. Moreover, this dirt contains an almost incalculable number of bacteria, and these are, of course, let loose in the milk as soon as the manure dissolves or the particles are parted by being soaked.

As a measure for the benefit of the cows it will pay to keep them carded and cleaned off to a fair state of respectability in appearance. Almost every farmer knows that it not only adds to the appearance of horses, but also to their general welfare, to keep them well groomed. The same is true of the dairy cow, and time spent in cleaning her is profitable for the welfare and health of the cow, even when the cleanliness of the milk is not considered.

In the best dairies engaged in supplying particularly good milk to a high-class trade, still greater precautions are observed to keep dirt from falling into the milk from the side and udder of the cow. Ever milker has noticed that during the process of milking, no matter how clean the cow, a small quantity of hair, dirt and dried scales will fall into the milk. This is prevented by rubbing the flank and udder of the cow with a damp cloth just before milking. Dust or hair will not fall from a damp surface. The cloth for this purpose should not be so wet or damp that water will drip from the udder, and the washing or dampening should not be done so long before milking that the udder will be dry before the milker gets to the cow. Neither should milking be done with wet hands, as dirty milk will drip from the hands into the bucket.

Many dairies also require milkers to wear white suits when milking and keep themselves scrupulously clean. The dairy which furnishes the the milk for the Walker-Gorden laboratory in Baltimore requires its milkers to put on a clean white suit every morning and wash their hands after milking each cow. This is of course unusual and would be far too expensive for the ordinary milk producer, but it shows plainly what is considered necessary in supplying the most exacting trade. It might be well to mention in this connection that many dairies have built up a desirable and paying patronage by following such methods, and advertising the fact. They, of course, get a much better price for their milk, and they almost universally say that they have a much greater demand than they can supply.

The following table will show the effect of dampening the cow's udder and flank on the number of bacteria in the milk:

TABLE I.

Trial	Bacteria per cc. Udder dry.	Bacteria per cc. Udder damp
1	2,700	1,100
2	2,200	2,000
3	2,000	1,000
4	3,000	3,000

These samples were obtained by milking two teats of the cow while the udder was dry, then dampening the udder and milking the other two teats. These samples of milk were set at the same temperature and there was a noticeable difference in the time of souring, favorable to the milk which was drawn when the udder was damp.

The third of the causes mentioned as affecting the number of bacterria in milk refers to the air. Bacteria cannot grow in the air for the simple reason that there is no material in the air to furnish food for them. But there are very few conditions under which the air does not contain a considerable number of bacteria. As they cannot grow in the air, it is evident that they must come from some other source. It can be taken for granted that wherever there is any dust of any kind, whether it be from the earth or from hay or straw, there is a large number of bacteria, and if this dust is stirred up into the air the bacteria are, of course, stirred up with it. The nearer the air comes to being free from dust, the less bacteria it will contain. Because of this, sweeping should never be done in a stable less than two hours before milking, bedding should be put in a considerable time before or after milking, and hay should never be fed just before milking. The bacteria found in hay and straw quite frequently are the cause for a number of different undesirable changes other than souring which sometimes occur. It must be kept in mind that souring is not the only thing to be guarded against in caring for milk. Souring is a natural change and does not denote anything except that the milk has not been kept at sufficiently low temperature. Other changes aside from the souring are likely to be sufficient proof that the dairyman is filthy or employs filthy methods, and it is very likely that the retailer in the city would reject such milk as quickly and censure the producer as surely as he would were the milk sour.

The fourth and last way in which bacteria get into the milk is through improper washing and cleaning of the utensils used in handling the milk. This is very likely one of the most fertile sources of contamination. If a little dirt remains in the corners of the cans or buckets, the bacteria will develop in great numbers and will spread through the milk as it is brought into contact with the can. The number of bacteria that can get into milk in this way is simply incalculable. The strainer, in particular, needs to be looked out for. A great many persons use cloth strainers. The meshes of the cloth hold a considerable quantity of milk which cannot be entirely washed out with cold or merely warm water. When this strainer is hung up in a warm place during the day, bacteria could not find a more favorable place to grow. For proof of this, notice the smell of an unscalded strainer after a particularly warm day. It has an odor between sour milk and decaying cheese, which is caused by the spoiling of the milk left in the cloth. There are millions of bacteria there ready to go into the can with the fresh milk.

There is reason to believe that the insufficient washing given dairy utensils and strainers results in more harm to the keeping qualities of the milk than the other three sources of contamination combined. The reason is not hard to explain. The most common way that milk spoils is, of course, by souring. This souring is caused by only three or four species of bacteria, as none of the many other kinds which get into milk have the power to act on the sugar and change it to an acid. It has been found within the last few years that but a very few of the bacteria which cause souring, get into the milk from the udder or from dirt clinging to the side and udder of the cow. There are, however, a great number of these lactic-acid-forming bacteria present in dirty cans and buckets, and they would, of course, get into the milk and cause it to sour decidedly quicker than it might otherwise.

To insure that tinware and strainers be free from bacteria requires something aside from clean washing. Good washing will remove the greater number of them, of course, but to get rid of all of them, or practically all, the utensils must be treated in some way to kill them outright. This can be done in three different ways. Turning tinware bottom up over a steam jet is the best, but very few farms have the convenience of steam. Another way often practised is to pour boiling water into the can. This would be efficient if there was a plentiful supply of boiling water and it would stay at the boiling temperature. But where there are a number of cans to wash, the water becomes too cool to do good service before it gets to the last few cans. Taking into consideration, too, that not a very large quantity of water is used, as a rule, the conclusion is that the boiling-water treatment is little better than no treatment at all, especially where there is any number of cans, buckets and strainers to clean.

Where steam is not available, probably the best means of insuring the destruction of a majority of the bacteria in the utensils is by using a warm solution of some of the well-known washing powders. The efficiency of these compounds was worked out at this station, and the results and conclusions published in Bulletin No. 79.

A good method to be followed in cleaning the tinware would be as follows: Wash first with water, at about ninety to one hundred degrees, with a stiff brush (never use a cloth for washing tinware of this sort). The brush will get into all corners, and when there are any dried particles of milk sticking to the sides it will scratch it loose. One precaution to always be observed is never pour hot water into a can before it has been washed with warm water, as the hot water cooks the milk to the side of the vessel and makes the washing more difficult. After washing thoroughly with warm water, rinse thoroughly with warm or hot water in which washing powder has been dissolved at the rate of one pound to fifteen gallons of water. After the vessels have been treated in this way, they should be rinsed out with a little cold water to free them of the washing-powder solution. This treatment is much easier than it reads; in fact it requires but very little more work than when the steam jet is used, and is nearly as efficient. The expense for washing powder is hardly worth considering. It might be stated in passing that where there is any disinfecting to do around a dairy, these washing powders are efficient and safe, and have none of the objectionable features attached to many of the other well-known disinfectants.

It is not to be understood that the farmer producer is alone to blame for the faults that can be found with the care of dairy utensils. The great majority of buyers in the city have considerable to learn that might well be put into practice in helping to get a good milk supply. Perhaps one of the greatest troubles and most fertile sources of poor milk comes from the way cans are returned to the farmers. The little milk remaining in the cans after they are emptied, of course, sours, and in the hot sun dries and cooks to the side, making it exceedingly difficult for them to be washed thoroughly clean after they reach the farm. All retailers should, without fail, wash all cans as soon as they are emptied at the city dairy. The majority of the better dairies are supplied with plenty of hot water and steam, and it would be a comparatively easy matter for the cans to receive a much more thorough cleaning than they would be likely to receive on most of the farms. The dairies owe it to themselves and their customers to follow out this practice, and producers are justified in demanding it. Returning cans unwashed to the farmer is undoubtedly one of the things that accounts for a good share of the poor milk shipped into cities. It is a very poor example for the city retailer to set for men who supply them with milk, and he undoubtedly suffers accordingly.

The actual benefit of observing these precautions in keeping the milk free from bacteria, and thus in a measure insuring better keeping qualities, can be seen from figures which have been gathered together concerning the number of bacteria in milk under varying conditions. The number of bacteria found in milk of course diminishes as the temperature of keeping approaches the zero point, but in actual practice likely the purest milk found on the market is that furnished by the Walker-Gordon laboratories of different cities. It is claimed that the maximum number found in the milk in the Walker-Gordon laboratory, of Baltimore, is 400 per cubic centimeter. This is exceedingly low, considering the figures that are to follow. It is very likely that under the most cleanly ordinary conditions which might be considered practical for the ordinary milk shipper, 4,000 bacteria per cubic centimeter would be the maximum number. The number which may be found in fresh milk from any source, of course, would vary entirely with the degree of cleanliness observed, but it could and does run as high as 50,000 per cubic centimeter, and occasionally more.

Of course, in the foregoing discussion many of the features considered are rather ideal, though they are practised by the very best class of dairymen, who are getting a sufficient price for their milk to warrant their going to the extra expense.

The following points should be observed by even the most humble dairyman, to insure getting a quality of milk on the market that will not be turned down by the buyer:

1. Keep the cows clean, for it pays with the cows.
2. Stir up no dust at milking time.
3. Take special care in washing and sterilizing tinware and strainers.

The point concerning the cooling of the milk and holding it at a low temperature will be brought out in succeeding pages.

PURIFYING MILK.

A number of different ways have been considered for reducing the amount of dirt and the number of bacteria in the milk. The first and most simple, of course, is that of straining. Strainers are obviously of little effect in removing any of the bacteria from milk except that which might be clinging to the hair, and other foreign material which can be strained out; therefore, the most efficient strainer is the one which will most thoroughly remove the dirt and mechanical impurities.

The two most simple-strainers are a cloth fastened over the mouth of the can and through which the milk is poured; and a fine wire mesh which may either be fastened to the milking bucket or set in the bottom of a funnel shaped tin which sets in the mouth of the can. There is an objection which may be raised against these strainers. After one lot of milk is strained, the dirt, of course, settles on the upper surface of the cloth or screen. In pouring the next bucket of milk into the strainer the milk drives hard against the accumulated material and has a tendency to force it through the mesh into the strained milk. A number of strainers have been made to do away with this difficulty. The first way thought of was to put the screen in the side of a cylinder which was placed at the bottom of the funnel-shaped tin structure, and have the bottom of this cylinder made of solid tin. The milk when it was poured in would strike the tin at the bottom and would not have so much force in driving the dirt through. This was doubtless some improvement over the original style. This second style was followed by many other ideas, some of them rather complicated. Possibly the strainer that embodied the best idea was one where the milk flowed upward through two strainers of very fine wire mesh. This prevented any agitation of the milk in the bottom of the strainer where the dirt collected, and the milk flowed out so gradually through the fine wires that a minimum of dirt or hair would be carried through. The strainer did not prove entirely practical, however, because a number of rubber rings were required to furnish air tight joints and it is almost impossible to find anyone who would take sufficient care in putting the parts together to make it do efficient work. The Station used one of these strainers for a number of years and it was found that when ordinary laborers were intrusted with putting the strainer together it would seldom do good work.

Some of the strainers put on the market in Germany have as high as six different wire meshes for the milk to flow through, with intervening pockets into which the dirt can settle. But a strainer which will do as good service as can be expected from any goes back to the old form with the wire strainer directly at the bottom of the funnel, while under the wire it is arranged so a number of thicknesses of cloth can be attached. In some cases a layer of absorbent cotton is placed between the layers of cheese cloth, and the milk has to flow through this. This is likely as efficient and practical a strainer as is used in any place, and it has the advantage of being cheap. In choosing a cloth to be used as a strainer the finer the weave, of course, the better it will be. A fine woven cheese cloth is used because it is cheap, and, while having a fine weave, still allows the milk to run freely.

No one, of course, will dispute the necessity of straining milk even under the most careful conditions, for it is impossible to keep hair and dried scales from falling into the bucket. Some experiments upon the effect of straining was made by W. A. Stocking, Jr., (Storrs Agr. Expt. Sta. Rpt., 1901) and showed that while unstrained milk had .0593 grams of dirt per liter of milk, strained milk had .0317 grams of dirt per liter. The milk at Storrs had much less dirt than usual, and it is likely that under ordinary conditions straining would be even more efficient.

CHARACTER OF MILK BUCKETS.

The ordinary milk buckets used in most dairy farms are the flaring open-topped type. Within the past few years, buckets with covered tops have come into use and have proven to be quite efficient in excluding dirt from the milk. These covered buckets usually have a funnel-shaped part that goes under the udder. Frequently this funnel has a strainer attached, and the milk is strained in addition to having the dirt excluded by the cover. One bucket that the writer has used had a spout at the side into which the funnel was inserted, the top of the bucket being used as a stool. This was an entirely satisfactory type of bucket.

The effect of a covered bucket in keeping the dirt out of the milk was demonstrated by Stocking in the same report as that giving the result with strainers. He found that in an average of fifteen trials there were .1103 grams of dirt per liter of milk in the uncovered bucket and .0408 grams of dirt per liter of milk in the covered bucket.

In this work with the covered and open buckets Stocking secured some rather astonishing and inconsistent results. He found, for instance, that the milk from the covered bucket and with the least amount of dirt in it did not keep as well as the dirtier milk in the uncovered bucket. He found that there were more bacteria in the cleaner milk. The worker with milk is often puzzled by apparently inconsistent results. It would be interesting to know why the uncovered milk should keep better than the cleaner milk. Stocking does not attempt to explain it, and it is doubtful if a rational explanation could be offered with the present knowledge on the subject.

FILTERING MILK.

An apparatus which is resorted to for removing dirt from milk is the filter. As all dirt can be filtered from water with very little trouble, wonder is often expressed why the same means cannot be employed to purify milk. There are two reasons for this, one of which is well understood, the other being seldom recognized. It is impossible to filter the bacteria from milk, because a part of the constituents of the milk, principally the fat, are not in solution, and any filter which is small enough to catch all of the bacteria would also hold the fat globules, which are larger than the bacteria.

In Europe a very large part of the milk is filtered through sand filterers, which aid materially in removing a part of the dirt and naturally some of the bacteria from the milk. The milk supply of some of the European cities is under control of the city authorities, making it possible for a uniform milk supply of a relatively high standard. This is particularly the case in Vienna, where perhaps the finest dairy for the handling of the milk supply of any city is located. All of the milk, practically, which goes to the residents of Vienna is filtered through sand. These filters are simply large drums filled with sand, and the milk either flows down by the force of gravity or is forced upward from the bottom of the filter and runs out at the top. These filters give fair service, but not as good as might be expected by any means. Water filtered through as deep layers of sand as are used in this particular dairy will come out pure; but milk has a strange affinity for dirt and seems loath to give up that which it holds in suspension. A peculiar exposition of this characteristic of milk was noticed in some work done at this Station in trying to remove the garlic odor from milk. The milk was filtered through bone-black, but came out as black as the charcoal through which it had passed. Water, made turbulent by the finest clay, was run through this same filter and came through clear as crystal. It was finally found that charcoal, granulated and washed as free from dirt as possible by agitating in water, would still cause the milk to turn black when run through it. To this same characteristic is very likely due the fact that the best sand filters will not remove all of the dirt from the milk.

Filters seem never to have come into use in this country, or there has at least never been any report of their use as far as could be found. It is very likely that if ever the cities of the country control the handling of the milk sold within their limits, the sand filter will be used as it is in Europe, providing some better means has not by that time been found for purifying milk.

USE OF THE SEPARATOR FOR PURIFYING MILK.

Who first employed the separator as a means of removing dirt from milk is a little hard to determine. That it should come into use for this purpose was natural, as anyone who has ever washed a separator has noticed the layer of matter that gathers on the inside of the steel bowl. This sediment is very dark colored in the case of dirty milk. The natural conclusion was that a relatively large proportion of the dirt of the milk was gathered with this separator slime, and analyses of the slime has shown that to be the correct conclusion. Actual experiments have shown the separator to have considerable power in removing foreign material, such as manure, from milk. There have, however, certain points been brought out by experimenters and others which leave a little doubt as to the real value of the separator to the milk seller. As was mentioned, experiments and analyses have proven that the separator removed a considerable proportion of the dirt from the milk. The work which illustrates this to as good advantage as any was by Dunbar (Milch Ztg. 1898, p. 771). The following table shows the result obtained by him:

TABLE II.

Milligrams Dirt in Liter of Milk.

Trial.	Before Separating.	After Separating.
1	6	1.0
2	10 5	1.0
3	18.0	0.5
4	18.5	2.0
5	8.0	2.0
6	8 0	0.0
7	2.5	1.0
8	4.5	0.5
Total	76.0	8.0

Percent. remaining, 10

The foregoing table would go to show that the separator could be depended on to remove all but a very small per cent. of the dirt. A number of trials were recorded where a relatively large quantity of dirt had been purposely added to the milk before separating, with practically the same results shown in Table II. Considering this result, if milk was sufficiently dirty it would pay to run it through a separator from the standpoint of common decency.

A number of trials have been made to determine the effect of the separator on the bacteriological content of the milk with varying results and also in this connection the keeping qualities of the separated and unseparated milk have been noticed. Dunbar in the same article in which he treats of the dirt removed from the milk by the separator, gives his results with the separator on the germ content of the milk. He seemed to get a decided increase in the number of germs to be found in the milk, but as this is, of course, an impossibility under perfect conditions, there must have been some factor that Dunbar did not take into consideration and which makes his work valueless. It may have been that he did not have his separator completely sterilized.

Eckles (Iowa Sta. Bul. 59) reports the results of experiments in determining the effect of separating milk on the bacteria and the keeping qualities of the milk. He found that the separator removed about half of the germs from the milk. But though it seemed to have this effect, it did not increase the keeping qualities of the milk, the separated and the unseparated samples souring at the same time. This appears as a rather peculiar result, for which an explanation will be offered further along.

The first time any question of the value of running milk for a city trade through a separator was called to the writer's attention was about three years ago. The practice had been so unqualifiedly recommended by prominent dairy investigators that a couple of well known Baltimore dairies, a little more up-to-date than the majority of concerns, and who were anxious to build up a trade for a good article, put in separators to use on the milk of their entire trade. These had been in use but a short time when complaints were made by both establishments. They claimed that the separated milk was not giving as good satisfaction as when it did not have this treatment. Two faults were found. The lesser of the two was that the cream rose too rapidly on the separated milk and people who wanted the whole milk, rather than cream, objected on these grounds. The other, a very serious objection, was that the separated milk did not keep so well as when not so treated. Three reasons why this should be the case could alone be considered. One was that the separated milk did not have the same care as regards cooling as the other. Another was that the separator or some of the machinery used in the work was not thoroughly sterilized, and the milk became contaminated from this source. The third reason was that the separator might have some hitherto unsuspected and unconsidered effect on the milk which made it a more favorable material for the growth of lactic acid bacteria. One of the dairies making the complaint was cut out of the calculation in looking for causes because it was a little careless in cleaning utensils and in the handling of the milk. The other dairy did not present this trouble. It was scrupulously clean in every particular as far as could be found, and the separated milk was treated in every way practically the same as that which was not separated.

In studying this problem it was decided to carry on some simple experiments much like those which had already been carried on by other workers. The separator was thoroughly sterilized by steam and boiling water, as were all of the other utensils used in handling the milk. The separator used was the largest sized of the De Laval machines intended for hand power and had a tin reservoir to contain the unseparated milk. This reservoir was poured full of fresh milk, and after about half of it had run out samples of skimmed milk and cream were taken simultaneously and the sample of whole milk was taken within thirty seconds afterwards. These samples were held at room temperature and occasionally tested for the amount of acid developed and for the number of bacteria present. This milk was obtained from the Station herd and was about two hours old at the time of separating. The number of bacteria in the first plates made shows it to have been fairly pure milk from that standpoint. The following tables, III and IV, show the development of acid and bacteria in the milk run through a separator in comparison with milk not thus treated.

TABLE III.

Tests of the Development of Acid in Separated and Non-Separated Milk.

Trial.	Separated.		Not Separated.	
	First taken. Acid, %.	24 hours. Acid, %.	First taken. Acid, %.	24 hours. Acid, %.
1st		.20		.20
2d		.28		.26
3d		.29		.25
4th		.45		.45
5th		.50		.50
6th	.17	.29	.20	.28
7th	.16	.55	.175	.55
8th	.18	.335	.18	.32
9th	.175	.35	.19	.36
10th	.15	.40	.175	.40

TABLE IV.

Tests of Comparative Development of Bacteria in Separated and Non-Separated Milk.

Trial.	Separated.		Not Separated.	
	First taken. Germs per cc.	24 hours. Germs per cc.	First taken. Germs per cc	24 hours. Germs per cc.
1st	22,000	780,000	23,000	1,300,000
2d	23,000	180,000,000	27,000	160,000,000
3d	9,000	130,000	48,000	130,000,000
4th	32,000	580,000,000	40,000	490,000,000
5th	8,000	79,000,000	25,000	90,000,000

The numbered trials in the two tables do not correspond, as the determination of acid and bacteria was not all done with the same lots.

In explaining some of the results it is necessary to say that the separated milk was allowed to stand sufficiently long to allow all of the contained air to escape, or, in other words, to allow all of the foam to rise to the top, so there could be no variation in the amounts of acid due to not taking as large a sample, by weight, of the separated milk as the unseparated.

There were some decidedly novel and unexpected results in determining the amount of acid in the fresh samples. For instance, in the sixth trial the fresh separated milk had .17% of acid when titrated with deci normal solution of sodium, while the unseparated sample showed .20% of acid. This variation in the percents of acid in the fresh samples was noted in all but one of the trials. If this has been noted before by any other worker we have been unable to find any statement in regard to it.

There was no attempt made on the part of the writer to determine the cause of this variation in the amount of acid found in fresh samples of separated and unseparated milk. Marshall, in some work on aeration of milk (Mich. Sta. Spec. Bul. 16), noticed practically the same variation of the percents of acid in milk due to aeration, and according to analyses made by him in connection with his work the variation was due to the fact that the milk gave up considerable percent. of its carbon dioxide. It is very likely that the smaller percent. of acid found in the separated milk was due to the same change in the content of the carbon dioxide of the milk after it was separated. It would be hard to explain it on any other grounds. There can be but very little doubt that the separator has very much the same effect as an aerator. Anyone who has separated milk with an undesirable odor has undoubtedly noted how much more this odor seems to be increased as the milk goes through the separator. By putting the face to a level and in front of the spout that carries the skim milk away from the separator a strong draft of air can be felt coming from the spout and this air is heavily charged with any odor the milk may contain. Again, the foam which comes from a separator would seem to be an indication that considerable air is mixed with the milk during separation.

Just what takes place in the bowl of the separator, aside from the separation of the fat from the body of the milk owing to the centrifugal force of the revolving bowl, has seldom if ever been commented upon. That it would be possible for the separator to suck in air through the opening in the top of the bowl, is, of course, possible and probable. A lighted match held to the mouth of the cream spout shows that a great quantity of air is being sucked in. This air would have to be given off through the cream and skim-milk tubes, and would, of course, come out thoroughly mixed with the milk and cream.

Marshall further found that his aerated milk, owing to the absence of carbon dioxide, allowed the bacteria to multiply faster than in the untreated milk, with the result that the aerated milk spoiled faster. It is not desirable to go too much into the details of Marshall's work in this connection, as it will be discussed more thoroughly in the portion of the bulletin devoted to the subject of aeration. Table III shows that, though the acidity of the separated milk was lower shortly after separation than when not so treated, yet in four trials the separated milk had the most acid at the end of twenty-four hours, five had the same percent. of acid, and in one trial the percent. of acid was greater in the unseparated milk. From these results it certainly appeared that the running of milk through a separator did not add to its keeping qualities. The effect of the aerating which it seemed to give to the milk will be discussed under that topic. Attention might be called, in passing, to the fact that the results seem to be a little different in some ways than the results of other workers. Table IV shows that the separating seemed to have a decided effect in reducing the number of germs in the fresh milk. And it would also appear from the table that the bacteria did not increase quite so rapidly in the separated milk. These results practically confirm the results of other workers.

Another point that is sometimes brought out in connection with milk which has been run through a separator, is that there does not appear to be so much cream rise on the milk after this treatment as when it is not run through a centrifuge. It must be understood that in all of this work the milk is run through a separator the same as though it was desired to secure the cream separate from the skim milk. But as the cream and skim milk come from the machine they are run together in the same receptacle and thoroughly mixed. This leads to the cream rising more rapidly than it would had the milk not been so treated. It also accounts for the fact that the "clarified" milk, as it is frequenlty called, does not show so much cream apparently as when it is not run through the separator, as the cream which does rise is thicker or has a greater percent. of fat.

Work has been done to see if the separator had any effect in removing the tuberculic organisms from milk. Moore (Year Book, U. S. Dept. of Agr., 1895) carried on some experiments which showed pretty well that, while the separator might remove part of the tuberculous germs, it could not be depended on by any means to remove enough to make the milk noticeably less harmless in this respect than it was before separating.

The great and important point is to decide whether, in the light of these different experiments, it was desirable to clarify or separate milk for the great bulk of the city trade. All of the different experiments should be taken into account in deciding this point. There is no doubt but that the separator removes the greater part of the dirt from milk. On the other hand, clarifying is valueless as a precaution against disease, and evidently has a tendency to cause the milk to sour more quickly than when not so treated.

For a special purpose or in special cases where the milk is so dirty as to make indecent food, separating is, of course, to be recommended. But in this State the prime consideration is to get the milk to the consumer with such treatment as will cause it to keep for the greatest length of time possible under our conditions, and the work at this Station would go to show that the separating is likely to injure rather than help the keeping qualities. Milk that is obtained under conditions which are anywhere near decent would not need separating to remove the dirt, for the amount of dirt present would be so small as to make the use of the separator superfluous. As far as our knowledge goes at the present time it is very doubtful, considering the extra expense and the other points brought out, if the use of the separator is worth while. There are very few of the large retail dairies in this country which use the separator and a number which have used it have discarded it for apparently sufficient reasons, after the apparatus for the work had been established. Until at least further evidence or knowledge is at hand it is likely that money spent in separators to purify milk is not money wisely expended.

AERATING MILK.

The aeration of milk is practiced extensively by dairymen and milk dealers. The practice has grown up in this country perhaps within the last twenty-five years, while only for the last ten years has it been sufficiently extensive to attract much particular attention. Within the last ten or fifteen years the subject has been very freely discussed by agricultural papers; and has been almost universally advised as worthy of the time and expense of dairymen, by the body of dairy experimental workers and teachers. And yet there has never been any very adequate reason given why the practice should be universally recommended as being necessary for the production of first-class dairy articles. It is known that milk quite frequently has undesirable tastes and odors when it comes from the cow, and takes up a variety of odors if the can is allowed to stand in the region of the material giving them off. As nearly all of these odors have a tendency to be given off, it is, of course, evident that if the entire body of milk could be brought into contact directly with pure air it would be much benefitted. Applied for this purpose the aerator is nothing of a mystery and its application and usefulness are at once apparent. Every dairyman knows that when milk is first drawn from the cow it has a distinct animal odor that to many people is very disagreeable. The aerator has been advertised as a cure for this supposed evil, and will undoubtedly remove the objection much quicker than though the milk was allowed to stand without going through the treatment.

Aside from these uses of the aerator which are easily understood and appreciated, it has been recommended that all milk should be aerated.

That it makes the milk keep longer, that better butter and cheese can be made from aerated milk, in fact, that it is better in many ways than any other, though the untreated milk be perfectly normal. No reason could be assigned for this supposed favorable action, and in the light of present knowledge one wonders if many of the claims made for the process were not due to a mistaken idea of the actual condition.

There has been a number of types of aerators put on the market—none of them very complicated in construction, as the process cannot be made other than very simple. Even during the milking of the animal the milk is brought in contact with the air and has considerable of the animal odor removed in this way. Simply dipping the milk from a can and pouring it from a height will aerate it to some extent and has been advised. Most of the aerators consist of a simple tin reservoir set upon legs and perforated with small holes. The milk is poured into the reservoir and drops through the holes into a can beneath and receives quite an efficient aeration. Another style is where the milk runs in a thin film over a metal surface. Usually in this style cold water is applied to the other side of the metal surface and the milk is cooled as well as aerated. But probably the best and most efficient style of aerator is one where air is forced by bellows to the bottom of the vessel and bubbles up through the mass of fluid. This style will remove nearly all of the odors that milk takes up in any way, either through what the cow eats or what the milk absorbs after it is drawn. It will not, however, entirely remove garlic. This aerator has been installed in factories and used on the entire quantity of milk as it is received. It is very likely that there are many instances where it has done some very valuable service.

Aside from removing odors the value of an aerator naturally centers on the keeping quality of aerated milk. The dairyman is interested in this particular feature, and a few experiments have been carried out to determine this point, and also to determine the value of the aerator in helping to produce good dairy products.

Dean (An. Rpt. Dept. of Agr. of Ontario, Vol. I, 1898, p. 34) carried through seventeen trials in determining the effect of aeration on the quality of butter. In these trials half of the milk was aerated, and the other half was made into butter without aerating, with the result that the butter from the aerated milk did not score so high on the average. Unfortunately the details of this work were not given. Dean states in conclusion that the milk used was clean and pure, presumably much more so than the milk from ordinary sources. The statement is made that ordinary milk should be aerated for the best results. The same worker tried the effect of aerating on the quality of cheese, and found as a result that it had practically no effect.

Wing did some interesting work testing the keeping qualities of milk with and without aeration. Three aerators were used—the Star, the Champion, and a make which aerates by forcing air to the bottom of the receptacle holding the milk and allowing it to bubble up through the mass of the fluid. In these trials the milk was cooled as well as aerated with the Star and Champion aerators, ice being used in the Champion and running water in the Star cooler. The milk aerated by the other aerator was not cooled more than a very few degrees by the air with which it was brought in contact. Samples of milk from each of the aerators were taken and compared in keeping qualities with a sample not aerated and evidently not cooled. The samples from the aerators which cooled the milk naturally kept longer than the unaerated milk, while the milk aerated and not cooled kept the same length of time as the unaerated.

Except in the case of the milk aerated with the apparatus which forced air through the milk, these tests were manifestly unfair, as with the Star and Champion aerators the milk was cooled to a very low temperature and held in comparison with samples which had not been cooled and which were allowed to cool naturally in the air. It required some time for the uncooled milk to reach the temperature of the air in which it was kept, and during this time it was going through a rapid change, owing not to the fact that it had not been aerated, but to the fact that it had not been cooled. The cooled and aerated milk was at or below the temperature of the air when it was set, and did not go through such rapid changes owing to the fact that it had been cooled rather than that it had been aerated. To have made a fair test of the efficiency of aerating, the unaerated milk should have been set in ice-water and cooled as rapidly as possible to the temperature of the aerated and cooled milk. As the test was made it was simply one of determining the variation in the time of souring of samples of milk set in small flasks at the same temperature, the milk being cooled in the one instance and set at body heat in the other. Owing to the impracticable or unusual way it was set, small flasks instead of cans being used, the experiment was of doubtful value even as a test of the value of rapid cooling.

Attention should be called to the use of the aerator which forced the air through the milk. In this case the milk was cooled very slightly, but, on the other hand, this style of aerator is known to be one of the most efficient for aerating purposes. This fact is evident from the way it eliminates bad odors from the milk. In this case samples of the milk were set practically at the same temperature with the unaerated milk, making it a test of the keeping qualities of aerated and unaerated milk without any other disturbing factors. It is significant in this case that the aerated milk kept no longer than the unaerated, and we cannot conclude from that that the aeration itself has no beneficial effects whatever on the keeping qualities. Judging from the other work that has been done, this is likely the usual results that would be obtained in aerating under normal conditions.

Possibly the most extensive study that was ever made of the effect of aerating milk was done by Marshall (Spec. Bul. No. 16, Mich. Expt. Sta.), who went deep into the subject of the effects of changes that take place in milk in aerating. His work, while exceedingly technical, nevertheless gave some practical results. He found that aerating removed a very large percent. of the carbon dioxide of the milk. This fact in itself could hardly be of any benefit to the milk, as carbon dioxide is not recognized as a harmful gas when taken into the stomach. On the other hand, highly carbonated drinks are supposed to be particularly healthful at certain seasons of the year. He reasoned, from this fact of the change of the amount of carbon dioxide, that in case milk had taken up any bad odors during milking, or had anything the matter with it owing to disease of the cow, aerating it in a pure atmosphere would tend to drive off the undesirable gases as well as the carbon dioxide. Marshall is doubtless correct in this supposition, and it shows the need of aerating under some conditions to make the milk entirely palatable and wholesome.

But Marshall found out a few more facts that are not so encouraging to the aerator. He found that the presence of carbon dioxide in the milk had a tendency to check the growth of bacteria and thus to keep it from souring for a greater length of time. Or, in other words, aerating caused the milk to sour more quickly than when not aerated. Marshall called attention to one theory, of interest to milk consumers, which was evidently in favor of aerating, and that was that it supplied more oxygen to the milk, and while it made it possible for it to sour more quickly, it made it impossible for poisonous ptomaines to develop.

It must be remembered, in considering Marshall's work, that the conditions under which it was carried out were ideal. The milk was obtained from the cow in such a manner that it could not come in contact with the air, and, as was stated before, during the process of milking, the milk receives considerable aerating. He furthermore aerated the milk under certain conditions that would be impractical. The work was interesting and valuable, as it showed what might occur to a less degree in practical aerating. But it must be kept in mind that it would occur to a less degree in the practical process.

To get a little more information than was at hand already, concerning the effect of aeration on the keeping qualities, a simple experiment was planned at this Station. In this work the Star aerator and cooler was used, and the milk was cooled as well as aerated. A full head of milk was turned on the aerator, as would be done in practice. About a half pint of the aerated milk was set at room temperature in comparison with a sample cooled as quickly as possible by putting the glass flask containing it in ice water. In this manner all conditions affecting the two samples of milk were the same except that of aeration. The samples were kept at the same temperature, but the temperature varied from day to day. The following tables show the development of acid and bacteria in the aerated in comparison with the unaerated milk when set at room temperature for twenty-four hours:

TABLE V.

Tests of the Development of Acid in Milk Aerated, in Comparison with Milk Not Aerated.

Trial.	Aerated. Acid, %.	Not Aerated. Acid, %.
1st	.60	.70
2nd	.25	.24
3rd	.25	.24
4th	.60	.58
5th	.25	.245
6th	35	.36
7th	.245	.245
8th	.21	.21
9th	.24	.24
10th	.22	.22
11th	.20	.20

TABLE VI.

Development of Bacteria in Aerated and Unaerated Milk.

Trials.	1st Taken	End 24 hrs.	End 48 hrs.
1st trial, aerated	1,000	19,000	6,000,000
1st trial, not aerated	1,000	25,000	15,000.000
2nd trial, aerated	6,800	25 000	18.000 000
2nd trial, not aerated	6 800	117,000	31,000,000
3rd trial, aerated	5 000	148,000	14,000,000
3rd trial, not aerated	5,000	400,000	14,000,000

Table V shows the percent. of acid present in the milk at the end of the period only. In every case tests for the percent. of acid were made with both the aerated and unaerated milk at the beginning of the experiment. The results were not noted down, as there was no variation in the acid due to the aeration.

Table V shows that out of eleven trials four of the aerated samples had more acid at the end of the period than the unaerated. Twice there was more acid in the unaerated samples, while in five trials the development of acid was the same. As far as practical results are concerned, it would appear that aeration had not a noticeable effect either way on the keeping qualities of the milk. These results vary somewhat from Marshall's, as he found the aerated milk to have less acid than the unaerated, evidently due to the giving off of the carbon dioxide during aeration. He further found the aerated milk did not appear to keep sweet so long as the unaerated. But, as was mentioned before, Marshall's conditions were ideal, while the conditions in the experiments here were practical. The milk aerated by Marshall was exposed to the air in a much thinner film and for a longer period than milk is when run over the ordinary cooler. Moreover, the milk used by him had not been exposed to a partial aeration through contact with the air during milking. This would account for his more pronounced results.

Table VI shows the results of the bacteriological studies made with the aerated and unaerated milks in three of the trials. The first sample in each case was taken from the aerated milk, and the number of bacteria in the freshly aerated and unaerated milk mere considered to be the same, as the aerator and all flasks and utensils were thoroughly scalded just before each trial. Marshall showed in his work that no bacteria were destroyed during the process of aerating. The three trials recorded are not identical with the first, second and third trials in the table showing the development af acid.

The table shows that if there was any difference worth mentioning, the aerated milk did not show as rapid development of bacteria as the unaerated. The difference was not sufficiently pronounced, however, to be definite. If any conclusions can be drawn from the table, it is that aerating has no particular effect on the development of bacteria.

In this connection with aerating, it is not out of place to again call attention to the probable aerating effect that the separator may have on the milk running through it. The reason for believing this is three-fold: first, the constant stream of air which seems to come from the skim milk spout of the separator, with the giving off of gases of tainted milk; second, the appearance of foam on the cans of skimmed milk and cream; and, third, the lower acid test of the milk after it is run through the separator. This last result corresponds pretty closely with the results obtained by Marshall in aerating. A chemical study of the gases of separated milk would doubtless be interesting as showing accurately what does occur during the process of separation, aside from the separation of the fat from the body of the milk.

The work of another man needs to be considered with this subject. Storch (Milch. Ztg., 1901, p. 253) conducted some extensive experiments to determine the effect of aerating on the quality of the butter. He found that in 56 percent. of the trials aerated milk did not produce as good butter as the unaerated. In 19 percent. of the trials the butter from the aerated milk was better, while in the rest of the trials there was no difference in the quality of the butter from the aerated and unaerated milk. This would rather lead to the conclusion that aeration harmed rather than benefitted. No mention was made of the source or character of the milk. It was likely from a very good source.

As in connection with the question of the advisability of running milk through a separator, in view of the conflicting opinions and the results of experiments, there is also some question of the advisability of going to the trouble and expense of aerating the milk. It would seem, from the actual experiments carried out at this Station and some of the results obtained by Wing, that aerating by itself cannot be depended on to add a particle to the keeping qualities of the milk. In fact, in view of Marshall's work, it is a question if aerating is not likely to have a tendency to the opposite effect and thus render the milk less resistant to undesirable changes. One thing must be kept in mind in considering this question, and that is, in aerating the milk takes up a portion of the surrounding air in exchange for its own gases. If the air is other than pure, the milk will take up the impurities with the air, and it is possible in this way to do the milk more harm than good. On the other hand, there is no doubt that aerating will remove undesirable taints when it is done in a pure atmosphere. In this connection and in view of all that has been said by various writers in favor of aerating, the following statement, written by Professor Dean, of the Dairy School at Guelph, Ontario, is interesting. Professor Dean made a statement in regard to aerating before the National Dairy Association at its annual meeting held in Milwaukee in 1902, in which aerating was condemned. The following letter was written at the request of the writer for the reason of this rather radical departure from popular opinion. The letter is as follows:

"Aerating milk on the average dairy farm in Ontario usually does more harm than good, because the aerating is done near the barn, or in connection with the milking yard, or in some place where the air is not pure. Therefore, the milk is in worse condition after being aerated than it is before. If the milk is clean and wholesome when drawn from the cow, to my mind aerating is of no value. The old idea of the oxygen of the air improving milk is, I think, pretty well exploded. The best way to treat milk, according to our experiments, is to cool the milk as rapidly as possible to a temperature of seventy degrees or below for cheesemaking and sixty degrees or below for buttermaking. This may be done by stirring the milk gently in the can, which is set in cold water, or it may be run over a cooler, such as the Lawrence, Star or Lister, and then be closed up tight. I think that the aerating of milk has received altogether too much attention, and that sufficient stress has not been laid upon proper cooling. I can understand that if there were any odors from feed, or from the cow herself, in the milk, that aeration in a pure atmosphere might help to eliminate these. Otherwise I can see no particular benefit in it."

It is very likely that the foregoing letter takes the correct view of the matter, and that the ordinary farmer is not justified in buying any of the ordinary types of aerators or of going to the trouble of using them. It is true, of course, that the Star, Lawrence and Lister coolers are in fact aerators, and it is not meant to include them in the condemnation of aerators in general. This function of cooling the milk quickly is an important one, and this question will be taken up later.

The place for the aerator is in the hands of the city dealer; thus, if milk is received that can be benefitted in removing foul smells by the use of the aerator, it should be used. The farmers, however, should strive to produce milk, which it is possible and easy to do, that will not need the aerator for the purpose of taking out bad smells.

PASTEURIZING THE MILK SUPPLY.

In discussing this branch of the subject, there is no intention of going into any details, but it is rather taken up to assign it a place in the general subject, and give an opinion as to the need or applicability of pasteurizing in the general city milk supply. Pasteurization of milk is the heating of the milk to a temperature and for a length of time that will kill the majority of the germs present without giving the milk a permanent cooked taste. There are different methods of heating the milk and a number of machines that have been made for the purpose, but these will not be discussed. There are two distinct objects of pasteurizing; one is to help the keeping qualities of the milk, and the other is to kill injurious germs, usually disease germs, which may be present in the milk. As far as our knowledge goes at the present time, in cases where there is any possible danger of the spread of the disease from the milk, pasteurizing should be practiced invariably, as serious epidemics could sometimes be avoided in this way; and milk which should not be consumed because of the danger of sickness, but which is all right in every other way, could be made perfectly wholesome by pasteurizing. In this connection some mention should be made of the liability of a good share of the milk, sold in the cities, spreading or inciting summer complaint in children. This could hardly be regarded as milk having disease germs and thus requiring pasteurizing to kill these germs. It is, however, usually dirty milk or very old and poorly-cared-for milk, and the treatment it needs is not pasteurization, but cleaner and better conditions on the part of the producer and retailer. That much of this milk would be better for infants were it pasteurized, there can be no doubt. But, on the other hand, the pasteurizing, according to work done at this Station (Bul. 77), renders the milk less digestible, and it is likely to bring about, for this very reason, the very condition which the pasteurizing was intended to avoid. Moreover, the additional cost of pasteurizing would be sufficient to buy a good article of milk which would not need this treatment to improve its wholesomeness, and would at the same time be better for not pasteurizing. This question, which affects the poorer quarters of the city, is one of the most serious to be confronted by retailers and city authorities in the whole dairy industry. This class of people are necessarily forced to buy the cheapest milk they can secure, owing to financial conditions. The mothers are driven by circumstances to spend the day away from home, and the babies are necessarily fed on this cheap cow's milk, with the result that the death rate is abnormally increased. The remedy, of course, is a pure milk, and this the dealer cannot and will not supply for the prices which the residents of the poorer quarters, through poverty and ignorance, are willing to pay. It seems that about the only solution is for the municipality to assume charge, in some manner, of this part of the retail trade. The producers could, if they would, combat this problem to a certain extent by not producing poor milk, but this state of affairs is too remote to consider.

There is not much doubt that pasteurizing milk adds to its keeping qualities, especially if the milk is of very poor quality; but there is a very serious question if, taking everything into consideration, practically as good keeping qualities in milk could not be secured by expending the same amount of money needed for pasteurizing, in producing cleaner and better-cared-for milk. To secure good results in pasteurizing makes quite an additional cost, and the opinion seems to be gaining ground that this same outlay expended in securing pure milk without pasteurizing would be much wiser. Pasteurizing has one serious objection not often mentioned. Pasteurized milk spoils usually without souring. The souring of milk is, of course, in a manner objectionable, and something that should be avoided as far as possible. But, on the other hand, the souring of milk under ordinary conditions is a warning that it is becoming too old for use, and, while it is comparatively harmless to the consumer in itself, it renders the milk unpalatable before any other serious fault may occur that would likely render the milk dangerous to the consumer. Pasteurized milk does not have this warning taste to guide the consumer, and extensive, even serious, changes could take place in it before the user could be aware, through taste, that anything was wrong. In fact, the first thing that can be noticed with the taste of pasteurized milk is when it commences to putrefy. Judging from these facts, pasteurizing the milk for the poor and ignorant of the cities would be likely to result sometimes in much more harm than good.

It is significant to note that pasteurizing has never secured a very firm foothold in the dairy industry in this country, and at the present time it appears very much as if it would never become general. It doubtless has its place and will be practiced in special cases for some time, but it will likely not spread to any great extent. The milk supply must be improved in some other way, and how that can be done economically and efficiently will now be taken up.

The condition which plays the most important part in the character of the milk supply of our cities is that of temperature, and the question of cleanliness is not excepted when this statement is made. Nearly every one, no matter how ignorant, who has ever had anything to do with milk, knows that it is much more likely to sour quickly in summer than in winter, and the warmer milk is kept the more quickly will it become unfit for use. It is furthermore known to many that by cooling milk to a sufficiently low temperature practically all changes in its taste could be checked, and it could be preserved in a palatable condition for a rather indefinite time, usually for several days or even weeks. But just what is the maximum temperature at which milk could be kept and remain sweet for this period, is seldom thought of by the ordinary dairyman and likely is known to very few of them.

There are a few other points which dairymen in general do not seem to consider, and one of these is the necessity for cooling the milk as quickly as possible after it is drawn from the cow. The usual practice on the majority of dairy farms is about as follows: Each mikler has from five to as many as twenty cows to milk. With the larger number it is impossible to finish the milking inside of two hours. Usually in milking none of the milk is cared for until all of the cows are milked. This means that with the larger number of cows the milk that is drawn first has to stand for two hours. On farms where no cooler is employed the milk is set in large cans either in running spring water or in ice water. It takes, with these conditions, practically from three to four hours for the milk to cool to a temperature sufficiently low to prevent rapid changes. Considering all this, part of the milk has been standing close to five hours at a temperature that will permit of quick souring, and the result is that it is almost sour before it becomes cold.

To thoroughly understand how much damage may be done by allowing milk to stand for any length of time before fermentation is checked by low temperature, a characteristic of milk must be noticed. For some unexplained reason, after milk is drawn the number of bacteria decrease for a period of time. This has been termed the germicidal property of milk. Two theories have been advanced as to the probable cause of this action. One is that the milk in itself has some distinct property that kills the bacteria, the same as well-known disinfectants kill them. The majority of bacteriologists believe that the decrease in numbers of bacteria in fresh milk is because a number of kinds of bacteria which get into the milk after it is drawn find it an unfavorable field for growth and naturally die off.

But to whatever this apparently germicidal property may be due, one important point is certain: the warmer the milk is kept the shorter is the time during which the number of germs in the milk decrease. If the milk is kept at ninety degrees, the decrease stops, and an increase in the number of germs begins in about one hour, while, if the milk is cooled to fifty degrees immediately after it is drawn from the cow, the decrease in the number of bacteria will sometimes continue through as much as fifteen hours. It is actually true that as far as bacteria are concerned, and likely in other respects, the milk will be better at the end of fifteen hours, or up to the time the germs commence to increase, than it was at first. Where the milk is cooled quickly after milking, it is as good or better at the end of this long period than it is at the end of the first hour when it is allowed to stand for the hour at animal heat, as is most often done on the farm. For warmer temperatures than fifty degrees the period during which the bacteria decreases in numbers varies. In the work at this Station it has been found that the number will decrease for from eight to twelve hours, if the milk is colored to sixty degrees while at sixty-five and seventy degrees the number may decrease for from five to seven hours, and then of course at these higher temperatures commence to increase very rapidly. A very few hours in the time that milk will keep sweet is a most important consideration during the summer season. The fourteen hours gained in the keeping quality when cooled at once to fifty degrees is longer than the entire period that it sometimes keeps. Even the five hours gained when the milk is cooled to seventy degrees is worthy of the effort.

To emphasize the effect of different treatment of milk on its keeping quality a series of experiments were planned and carried through at this Station. In this work a temperature of sixty degrees was used as a basis for practically all of the experiments. The reason for this is found in the natural temperature of the water from a great many wells of the State. This temperature quite frequently runs as high as sixty degrees, and as ice cannot always be counted on by many of the dairymen it was thought best to see what could be done in a practical way with water of this temperature and no ice. The results may prove a little interesting to some of the dairymen of the State who have had trouble in supplying good milk even when a plentiful supply of ice was at hand.

To get milk in a good condition into the Baltimore city market demands that it keep for varying lengths of time. All of the trains carrying milk arrive in Baltimore by nine o'clock in the morning and by eight in the evening. In the summer there is no excuse for milk older than twelve hours old being shipped unless the producer has plenty of ice. This would make the milk about fifteen to eighteen or perhaps twenty hours old when it reaches the city. The time the milk is in the hand of the city dealer need not, or at least there is no reason why it need be considered, for city dealers should be so supplied with ice and cooling apparatus that as soon, practically, as the milk is received by them it can be cooled to so low a temperature that no change would take place in it while in their hands. Moreover, they can have the milk so cold and use such precautions in delivering it that it will get in the hands of the consumer in as good condition as they received it.

Consumers keep the milk under varying conditions. Many of them have ice boxes which maintain a temperature of about sixty degrees in the hottest weather. The poorer people, of course, do not have ice. When there are babies fed on a bottle it is necessary that the milk keep for at least twelve hours after it is received. This is one of the hardest problems to meet, but the work done at this Station will show that it can be done without a great amount of care and without the use of ice when the milk is produced within a reasonable distance of the city.

The first work discussed will be that of milk cooled immediately to 60 degrees in comparison with milk set in running water at sixty degrees for from four to five hours and thus cooled to sixty degrees and held at that temperature with the other sample. The following tables give the result of these experiments;

TABLE VII.

Cooled Immediately to 60 Degrees.

Time of Trial.	1st Trial.		2d Trial.		3d Trial.		4th Trial.	
	Germs per cc.	Acidity %.	Germs per cc.	Acidity %.	Germs per cc.	Acidity %.	Germs per cc.	Acidity %.
First taken......	14,000	......	3,500	......	5,000	......	7,000	......
End 9 hours....	23,000	......	....	......	....	......	40,000	......
End 24 hours...	26,000,000	......	1,200,000	.17	12,000,000	.175	4,300,000	......
End 33 hours...	95,000,000	.23	....	.....	21,000,000	.21	50,000,000	.20
End 48 hours...	....	......	....	......	....	......	....	.26

Set in Running Water at 60 Degrees.

First taken......	14,000	......	3,500	......	5,000	......	7,000	......
End 4 hours....	....	......	....	.17	250,000	......	130,000	......
End 9 hours....	....	......	....	......	....	......	1,400,000	......
End 24 hours...	119,000,000	......	4,700,000	.18	38,000,000	.195	....	.18
End 33 hours...	145,000,000	.30	13,000,000	.21	210,000,000	.23	230,000,000	.23

TABLE VIII.

Temperature of Milk when Taken from Water.

Trial.	Time in Water. Hours.	Temperature. Degrees.
1st Trial	4	70
2d Trial	5	64
3d Trial	5	64
4th Trial	5	64
5th Trial	5	63

The general plan of this experiment fits very aptly the work as it is done on many dairy farms. Running water is nearly always employed where springs for the purpose are available. This experiment is a little more favorable to the milk set in running water than would be the case in practice, as at the end of a few hours the milk was removed and the sample kept for comparison was cooled quickly to sixty degrees. Had the milk been allowed to stay until it reached the temperature of the water as is actually done in practice the results would have been still more pronounced than they were in these experiments. In the first trial at the end of thirty-three hours there was a difference of .05 per cent of acid in favor of the milk cooled immediately. This would make, at that temperature, about three to five hours difference in the keeping qualities. There was also a difference of about fifty million bacteria at the end of the time. The most pronounced difference was in the fourth trial where the milk cooled immediately kept in fit condition for use for forty-eight hours and that cooled by standing in the running water kept for thirty-three hours only. It is likely that this is a little greater variation than could be expected as a rule, but there was very marked difference in the time the two lots kept sweet in all of the trials. It shows the importance of cooling the milk immediately after the cow is milked. The reason for this can be readily seen in table VIII where the record of the temperature is given. This table shows that at the end of five hours the milk was still four degrees above the temperature at which the other milk had been held for this length of time. Moreover, the milk set in the running water had been coming slowly to this temperature. It was set in the water when it was practically at animal heat and, of course had been reduced slowly to the temperature at which it was removed from the water. Most of the first hour the milk had been above 70 degrees which is very favorable for the souring of the milk. This would more than allow time for the milk to lose all of its germicidal properties and be started pretty well along the road toward souring.

In the bacteriological work of this experiment as in all of the experiments of this bulletin agar with twenty percent of lactose was used, while for testing the development of the acid, deci-normal solution of sodium was used with phenolthalein for an indicator. For the acid test the same quantity of milk was used as for testing milk, or eighteen grams. This required only that the amount of the deci-normal solution required to neutralize the milk be divided by two to get the acidity of the milk.

This makes a very handy and quick way of testing the acidity and will be mentioned again in another connection.

Another very common way for the farmer to treat the night's milk which is to be shipped the following morning is to set it in a tank of water without ice. This water is usually pumped fresh from the well to give it as favorable opportunity as possible. The trouble with this method is that when the warm milk is placed in the tank of water the cans of milk usually occupy about half the space in the tank, or there is about as much milk as water. The milk is at animal heat, and although the water is sufficiently cold as it comes from the well to keep the milk in good condition the warm milk soon brings the temperature up to too high a degree to be effectual. The tank has to be extra large in comparison with the amount of milk kept in it, and the night more than usually cool for summer weather if the temperature of the water and milk both do not stand finally above seventy degrees which is much too warm to insure milk keeping.

To note how inefficient this way of keeping the milk may be, an experiment was planned in which milk treated as above noted was kept in comparison with a sample of the same milk cooled immediately after it was milked, to sixty degrees, and held at this temperature. The milk was set in a five-gallon can such as is often used by shippers in a half barrel of water at sixty degrees temperature and was kept in this water for fifteen hours when it was. or a sample of it was, cooled to sixty degrees and held with the sample that had been cooled immediately after milking. The following table shows the results of this experiment;

TABLE IX.

Cooled Immediately to 60 Degrees.

Time of Trial.	1st Trial.		2d Trial.		3d Trial.		4th Trial.	
	Germs per cc.	Acidity %.	Germs per cc.	Acidity %.	Germs per cc.	Acidity %.	Germs per cc.	Acidity %.
First taken......	5,000	....	1,100	....	7,000	......	13,000	......
End 15 hours...	71,000	......	6,630	......	15,300	......	....	......
End 24 hours...	24,000,000	......	442,000	......	624,000	......	312,000	......
End 39 hours...	64,000,000	......	8,400,000	......	....	......	1,700,000	......
End 48 hours...	....	.28	60,000,000	.24	77,000,000	.24	50,000,000	.225

Set in Water at 60 Degrees for 15 hours, then cooled to 60 Degrees and held.

First taken......	5,000	......	1,100	......	7,000	......	13,000	......
End 15 hours...	1,100,000	......	280,000	......	2,500,000	......	910,000	......
End 24 hours...	29,000,000	.20	4,000,000	.....	69,000,000	.20	2,000,000	......
End 39 hours...	....	......	14,000,000	.....	300,000,000	.30	26,000,000	.21

TABLE X.

Trial.	Temperature of Milk, end 15 hrs.	Character of Night.	Time of Souring.
First	74	Warm	30 hours
Second	66	Cool	44 hours
Third	70	Warm	32 hours
Fourth	68	Cool	40 hours

As will be noted in Table IX samples were taken to determine the number of bacteria when the milk was fresh, at the end of fifteen hours, twenty-four hours, thirty-nine hours and forty-eight hours, and acid tests were made at the end of thirty-nine hours and forty-eight hours in the case of the milk cooled immediately.

In the first trial the milk cooled immediately to sixty degrees had 28 per cent of acid at the end of forty-eight hours and as this is slightly in excess of the amount of acid to be detected by a trained taste it is likely that the milk reached the point where it would be called unfit for use in about forty-six hours. It will be noted that the milk set in the tub had commenced to change in twenty-four hours, and it was thick in thirty-nine hours when the next sample was taken. This milk likely reached the turning point at almost thirty hours or even less. In the second trial the milk cooled immediately did not sour for almost fifty hours, while the milk set in the tub did not sour until forty-four hours, which, to say the least, was a little surprising. Referring to table X it will be noted that this was a cool night and the notes taken at the time particularly emphasize this fact. This coolness could have affected the milk in two ways. It could have caused it to cool faster and lower while in the tub and it could also have caused it to cool materially while standing in the cans during the milking and before putting it in the tub. This would have aided the germicidal property to extend over a longer period and would partially account for the seeming long period that the milk kept sweet. There may have been other causes impossible to explain, as milk is a peculiar substance and goes through some apparently very inconsistent variations at different periods.

The third trial the milk cooled immediately kept about fifty hours while the milk cooled in the tub of water soured in about thirty-two hours. Table IX shows this to have been a warm night as was also the night of the first trial which seemed to be the cause of the comparatively quick souring. In the fourth trial the sample cooled immediately kept more than fifty hours, while the other kept about forty-two hours, due to the fact that the night was cool.

One thing to be noticed in this connection is that of all the samples of milk cooled immediately there was not one but what was good for use practically two full days, which would give abundant time to ship milk for a long distance to a city and still be kept in good condition several hours after reaching the consumer. On the other hand, the milk cooled by setting in the tank of cold water could not be depended on to keep sweet longer than for thirty hours in hot weather. This would be ample for creamery purposes but is totally inadequate for a city milk supply.

The bacteriological study of this work shows where the milk set in the tub lost in keeping quality. For instance, noting the first trial at the end of fifteen hours there was only 70,000 bacteria to the cc in the milk cooled immediately, which was hardly a good start, while in the milk cooled in the tub of water there were over one million germs to the cc. In the second trial the milk cooled immediately showed but 6,600 bacteria to the cc at the end of the fifteen hours while the other had 280,000 bacteria in the same quantity. In the third trial it was 15,000 to 2,500,000. These results would show that the milk cooled immediately was barely beyond the point of time where the germicidal action of the milk had had the effect of reducing the number of bacteria. This is certainly the case in the second trial where it is quite evident that the bacteria had been increasing in numbers for only a couple of hours. On the other hand if one is to judge from the number of bacteria found at the end of fifteen hours in the samples of milk set in the tub, it is evident that the numbers of bacteria commenced to increase soon after it was put in the tub.

Possibly the very worst mistake that many dairymen make in the handling of their milk is in allowing it to stand for a considerable length of time before any move is made to see that the milk is cooled. Mention is made of this in previous pages, in giving the usual plan for caring for milk where the fact that farmers as a rule never cool the milk or start it to cooling until all of the milking is finished at which time the first milk has stood for from one hour to two hours. This gives the germicidal property of the milk a chance to quickly exhaust itself and the milk has really commenced to change rapidly before it is cooled. Some of the most careful dairymen make this mistake. Men who have ice and use it liberally, cooling their milk in the end to almost the freezing point neglect this more important point of cooling the milk as soon as it is drawn.

To determine just what effect allowing milk to stand for two hours before cooling had on it an experiment was planned in which a sample of milk was cooled to sixty degrees as soon as it was drawn while the bulk of the milk was allowed to stand for two hours without cooling when a sample was cooled to sixty degrees and held. Acid and bacteriological tests were made at intervals and the results are given in the following table:

TABLE XI.

Cooled Immediately to 60 Degrees.

Time of Trial.	1st Trial.		2d Trial.		3d Trial.		4th Trial.		5th Trial.
	Germs per cc.	Acidity %.	Germs per cc.	Acidity %.	Germs per cc.	Acidity %.	Germs per cc.	Acidity %.	Germs per cc.
First taken......	5,000	.....	4,000	......	19,000	......	30,000	.....	13,500
End 9 hours....	....	......	37,000	......	....	......	32,000	......	16,800
End 24 hours...	1,600,000	......	1,600,000	......	1,100,000	......	3,624,000	......	....
End 33 hours...	10,000,000	.19	11,000,000	......	20.000,000	......	10,000,000	......	....
End 48 hours...	....	.30	....	.25	78,000,000	.25	37,000,000	.23	125,000,000

Cooled after Two Hours to 60 Degrees.

First taken......	5,000	......	4,000	......	19,000	.....	30,000	......	13,500
End 2 hours....	56,000	.....	9,940	......	37,000	.....	64,000	......	21,000
End 9 hours....	....	......	390,000	......	....	......	700,000	.....	340,000
End 24 hours...	20,000,000	.20	22,000,000	......	1,000,000	.....	16,000,000	......	7,000,000
End 33 hours...	75,000,000	.24	....	.23	....	.28	....	.23	30,000,000

A study of Table XI shows some interesting results, and that in this case at least, theoretical and practical results are very similar. In the first trial the milk cooled immediately soured in about forty five hours while the milk which was allowed to stand for two hours before cooling soured in about thirty-five hours. At the end of the two hours the sample of milk that stood without cooling had 56,000 bacteria per cc while it had but 5,000 per cc to commence with. At the end of twenty-four hours this milk had 20,000,000 bacteria per cc while the other sample of milk had but 1,600,000 at the same time.

In the second trial the milk cooled immediately soured in forty-eight hours and the other milk soured in about thirty-six hours. This variation appeared to be fairly constant through all of the four trials and makes a pretty fair object lessen on the increased keeping quality of the milk when the milk is cooled immediately. It can be said for the foregoing experiment that the milk cooled immediately was not cooled so in fact but was cooled perhaps twenty minutes after the cow or cows were milked. Had it been cooled immediately there would have been slightly more variation in its favor.

Mention was made in discussing the work given in Table XI about the use of ice in cooling milk. This, of course, is to be recommended, but there are some fallacies in its use that it is just as well to call into question, and explain wherein the mistake is made. There is perhaps no condition in dairying where ice could not be used profitably, but the benefits to be derived from it do not come in the way that they are usually supposed to. Ice is employed in two general ways by the producer in dairying for a city supply, one of them being very common. The way which is perhaps the least used is to keep the ice in a refrigerator and set the milk in the refrigerator. The other and most common method is to partially fill a tank with water and ice and set the cans of milk in this. The advantages of the two systems will be discussed in subsequent pages. The water in the tank if sufficient ice is used, which is seldom the case should be practically at 32 degrees or freezing point. However, in practice a few large chunks of ice are placed in the tank, and it is very likely that the water does not get below forty degrees and the milk after it has remained in the water a sufficient length of time reaches the same temperature.

The effect of the use of ice on the keeping qualities of the milk will be illustrated in two lines of experiments taken up at this Station. One was to test the effect of setting milk without previous cooling in ice water over night in comparison with milk cooled immediately to 60 degrees and held at this temperature. The other experiment was to determine the difference in cooling a can of milk in ice water and cooling it to 60 degrees immediately, noting the length of time required for cooling the milk to 60 degrees in the ice water.

In the first experiment a half-barrel was filled with water and a large chunk of ice was put in it, the subsequent temperature being at about 40 degrees. The milk without previous cooling was set in a five gallon can such as is used for shipping in many places, and was allowed to remain in the ice water for fifteen hours, when a small portion of it was taken in a glass flask and held at 60 degrees in comparison with a sample of milk that had been cooled immediately to 60 degrees after milking and held at this temperature during the time that the other milk had been setting in the ice water. One would naturally expect that the milk set in the ice water would keep much longer than the other. The following tables show the result of a bacteriological study of this work;

TABLE XII.

Milk Cooled to 60 Degrees and Held.

Time of Trial.	1st Trial. Germs per cc.	2d Trial. Germs per cc.	3d Trial. Germs per cc.
First taken	210	4,500	830
End 15 hours	1,000	7,000	100,000
End 24 hours	7,000	290,000	210,000
End 39 hours	......	....	11,000,000
End 48 hours	......	13,000,000	45,000,000

Set in Ice Water.

Time of Trial.	1st Trial. Germs per cc.	2d Trial. Germs per cc.	3d Trial. Germs per cc.
First taken	210	4,500	830
End 15 hours	15,000	9,000	35,000
End 24 hours	37,000	85,000	180,000
End 39 hours	....	....	3,700,000
End 48 hours	....	31,000,000	39,000,000

Unfortunately, circumstances made it impossible at the time to make and present parallel acid tests of the milk. But the water taken at the time show that the milk set in the ice water kept a very little longer, perhaps a couple of hours, than the milk cooled to 60 degrees and held. This variation and the results of the bacteriological study are not as favorable as one would expect and it is very likely that the great majority of dairymen will be inclined to question it. There is a reason why the results should be as they are, and it is the reason that has been presented before. The milk cooled to 60 degrees and held was cooled within fifteen minutes after the cow was milked and the milk set in the ice water was not so placed until more than an hour after the beginning of the milking. Consequently the milk stood practically at the body temperature for this length of time, and after being put in the ice water cooled very slowly owing to the bulk of milk in the can and the comparatively small surface exposed to the cold water. Because of this standing at body heat and the comparatively slow cooling in the ice water the bacteria in the milk had very likely increased materially before it was cooled to so low a temperature that no more growth could take place, while on the other hand the bacteria in the milk which was cooled immediately actually decreased in number for a large part of the fifteen hours, with the result that at the end of the fifteen hours both lots of milk were on about an equal footing. Had the milk been cooled as soon as it was drawn to a reasonably low temperature and then set in the ice water there would have been a very great difference in favor of the milk where the ice was used.

The ice would, however, have had some effect on the keeping of the milk which is not illustrated in this experiment. If the milk had been shipped on a hot morning in comparison with a can of milk at 60 degrees, it would have required some time for the bulk of cold milk to be warmed up to temperature where change would take place, while the milk at 60 degrees would already be at a temperature permitting of souring and would be constantly getting warmer. This work illustrates, however, that ice does not play a favorable part in the way it is supposed. It can be taken as a correct statement that cooling milk below 50 degrees does not help its keeping qualities in a practical way, aside from the fact that it requires a longer period for the cold milk to warm up to a dangerous temperature during shipment, and all of the effort put forward by dairymen to get the milk so cold is largely wasted. Were it directed towards getting the milk cooled as soon as possible after milking much more favorable results would be obtained and at no greater expense.

As was mentioned, some work was done to determine how long a time was required for warm milk to cool to a temperature where rapid change would not take place, when the milk was set in ice water. In this work the conditions were made more favorable than would have been in practice, as the milk was set in a shotgun can which would allow of more rapid cooling than if the milk was set in the ordinary shipping can.

In these experiments, as in the others, samples of milk were cooled to 60 degrees immediately after milking in comparison with the milk set in the ice water. Sixty degrees was the temperature to which the milk was cooled and table XIV shows the length of time required for the milk to get to this temperature and also the variation in the time of souring. Table XIII shows the bacteriological study of the milk.

TABLE XIII.

Cooled Immediately to 60 Degrees.

Time of Trial.	1st Trial. Germs per cc	2d Trial. Germs per cc	3d Trial. Germs per cc.	4th Trial. Germs per cc.
First taken	2,500	7 000	5,000	620
End 9 hours	9.000	25,000	13,000	....
End 24 hours	468,000	2,600,000	3.200,000	402,000
End 33 hours	1,400,000	5,000,000	25,000,000	6,500.000
Set in Ice Water.				
First taken	2,500	7,000	5.000	620
End 9 hours	9,000	54,000	13,000	....
End 24 hours	....	4,300,000	5,000.000	121,000
End 33 hours	20,000,000	92,000,000	36,000,000	5,000,000

TABLE XIV.

Length of Time Required for Souring—Hours.

Trial.	Cooled immediately.	Cooled in can	Time required to cool to 60 in can.
First	48	42	2½
Second	45	40	2
Third	48	48	2
Fourth	48	46	2

Table XIV shows that it required from two to two and one-half hours for the milk to get to 60 degrees when it was set in a shotgun can in ice water, and this difference in cooling made as much as five hours difference in the souring of the milk. It might be stated here that this work was done during a rather cool spell and the milk had cooled considerably before it was set in the water. It would have made considerable difference had the weather been warm. Again, had a more bulky can been used to set the milk it would have required a longer period to cool and would have made still more variation. The conditions adopted and the state of the weather offered the best opportunity possible for the milk set in the ice water. In practice the conditions would have been more unfavorable and the variation in souring greater. This experiment further illustrates that the rapid cooling of the milk has considerable to do with the length of time it will remain sweet; and it also shows that setting in ice water cannot be depended on to cool the milk as rapidly as is best for its keeping qualities.

A bacteriological study as given in Table XIII shows that at the end of thirty-three hours the milk set in the ice water had the greater number of bacteria in it with the one exception. This agrees very well with the acid tests of the milk and is what could be expected to result from the different ways of caring for the two lots of milk.

TREATING MILK WITH A TEMPERATURE OF 65 DEGREES.

In addition to the work done with a temperature of 60 degrees as a basis, it was considered that work using a temperature basis of 65 degrees during the hottest summer weather would be interesting. There are possibly a few wells in the State that furnish water as warm as 65 degrees during the hottest summer weather. Furthermore, it is but a small space between 60 degrees and 65 degrees and unless the producer is exceedingly careful in hot weather the 60 degree water will become 65 degree water in the course of a very short period of time. The work with the 65 degree temperature was planned along the same lines as when water at 60 degrees was used. In the first experiment milk was cooled immediately after being drawn to 65 degrees and held at this temperature until souring, in comparison with milk that was allowed to stand for two hours without cooling, when it was cooled to 65 degrees and held with the other milk.

The following table shows the acid test and bacteriological determinations made with these two lots of milk:

TABLE XV.

Cooled Immediately to 65 Degrees and Held.

Time of Trial.	1st Trial.		2d Trial.		3d Trial.	
	Germs per cc.	Acidity %.	Germs per cc.	Acidity %.	Germs per cc.	Acidity %.
First taken	4,000	......	4,700	......	4,500	......
End 9 hours	2,100,000	......	2,000,000	......	3,300,000	......
End 20 hours	23,000,000	......	50,000,000	......	36,000,000	......
End 33 hours	....	.21	....	.26	....	.25

Cooled at End Two Hours to 65 Degrees.

Time of Trial.	1st Trial.		2d Trial.		3d Trial.	
	Germs per cc.	Acidity %.	Germs per cc.	Acidity %.	Germs per cc.	Acidity %.
First taken	4,100	......	4,700	......	4,500	......
End 2 hours	....	......	57,000	......	51,000	......
End 9 hours	5,000,000	......	2,000,000	......	15,000,000	......
End 24 hours	132,000,000	.20	297,000,000	.26	135,000,000	.20
End 33 hours	....	.28	....	......	....	.30

In the first trial shown in Table XV the milk cooled immediately soured in about thirty-five hours, while the milk which was allowed to stand soured in about thirty hours. In the second trial the milk cooled immediately soured in thirty-three hours and the other soured in twenty-four hours. In the third trial the milk cooled immediately soured in thirty-four hours and the other in about twenty-nine hours. This table illustrates, as have others, the advantage to be gained in quick cooling. Other phases of this work will be discussed after presenting the next table.

The next work was with milk cooled immediately to 65 degrees held in comparison with milk set in a tub of water over night at 65 degrees. The milk having had no previous cooling. The following tables give the result of this work:

TABLE XVI.

Cooled Immediately.

Time of Trial	1st Trial.		2d Trial.		3d Trial.	
	Germs per cc	Acidity %	Germs per cc.	Acidity %.	Germs per cc.	Acidity %.
First taken	2,000	.....	6,000	.....	4.500	.....
End 15 hours	3,000,000	.....	3,000,000	.....	2,700,000	.....
End 24 hours	20,000,000	.20	87,000,000	.19	13,000,000	.20
Set in Water at 65 Degrees.						
First taken	2,000	.....	6,000	.....	4.500	.....
End 15 hours	4.400,000	.....	6,000,000	.....	6,900,000	.....
End 24 hours	26,000,000	.25	136.000.000	.23	100,000,000	.24

Table XVI shows that milk set in a tub or tank of water at 65 degrees, the milk having no previous cooling, could not be depended upon in warm weather to keep longer than twenty-four hours. The milk cooled immediately to the same temperature kept from thirty to thirty-five hours. There would, of course, be considerable variation in the length of time the milk would keep when set in the water, depending on the character of the weather, whether it were cool or hot, as this would make considerable difference in the ultimate temperature of the water and milk. It is doubtful if in ordinary weather milk could be kept at this temperature for longer than twenty-four hours without an impractical amount of care bestowed in another way. The most important lesson to be gathered from this work is that a temperature of 65 degrees cannot be depended on to keep milk for a sufficient length of time to get it to the city market without the shipping point is close to the city and the milk is shipped twice a day. This is important to producers for they get careless about the temperature of the water thas is used. Even if the well furnishes unusually cool water, if it is allowed to stand for any length of time during a hot day it will soon get above the danger point, and for this reason it is a necessity that the water be pumped fresh for the milk at the time that the milk goes into the tank. Of course, where running spring water is used this point does not need to be guarded against, but it is something that the man who uses well water and has no ice needs to look after very closely.

MILK COOLED IN REFRIGERATOR.

Another piece of work taken up in connection with the keeping of milk varies a little from the other and applies perhaps to a limited number of producers during the summer months of the year. This work was in connection with the use of ice in refrigerators instead of in water tanks, the milk being set in the refrigerator for keeping instead of in cold water. The refrigerator can play an important economic part in the keeping of milk when it is rightly used, but when milk is set in it without previous cooling on the assumption that the low temperature of the refrigerator is sufficient protection against souring, it can be an abomination and result in more loss than gain. The fault lies in supposing that milk will cool rapidly when set in cold air. This is far from being the case, and in fact air has to be exceedingly cold, dry and constantly stirring to have much effect on the milk. Just the opposite effect in two of the points is experienced in a refrigerator. The air is moist so that no aid in cooling is given by evaporation. There is naturally very little circulation of the air, and, furthermore, refrigerators cooled by means of natural ice do not as a rule have a temperature lower than is necessary for the milk itself to have for good keeping qualities. For this reason the milk should be cooled before setting in the refrigerator.

To illustrate the effect of setting warm milk in a refrigerator, several trials were made of this way of handling the milk, in comparison with cooling it immediately to the temperature of the refrigerator and holding at that temperature. The temperature of the refrigerator was about 60 degrees and the following tables give the result of this work; the milk being kept in the refrigerator fifteen hours;

TABLE XVII.

Cooled Immediately.

Time of Trial	1st Trial	2d Trial.	3d Trial.		4th Trial.		5th Trial.	
	Germs per cc.	Germs per cc.	Germs per cc.	Acidity per ct.	Germs per cc.	Acidity per ct.	Germs per cc.	Acidity per ct.
First taken...	3,200	5.200	2,200	.18	3,800	.18	3,000	.18
End 15 hours	26,000	49,000	5,000	.17	2,900	......	27,000	......
End 24 hours	2,000,000	2,700,000	....	......	1,200,000	.....	167,000	......
End 39 hours	25,000,000	50,400,000	28,000,000	.195	17,000,000	.185	....	......
End 48 hours	....	....	61,000,000	.21	84,000,000	.23	65,000,000	.23

Set in Refrigerator.

Time of Trial	1st Trial	2d Trial.	3d Trial.		4th Trial.		5th Trial.	
First taken...	3,200	5,200	2,200	.18	3,800	.18	....	.18
End 15 hours	5,000,000	65,000,000	....	.22	12,400,000	.21	....	.21

TABLE XVIII.

Trial.	Temperature of Refrigerator.	Temperature of Milk, end of 15 hours.
First........	60	68
Second........................	62	74
Third	60	70
Fourth	60	68
Fifth..........................	60	68

It will be noticed that in the different trials the milk cooled immediately after milking kept for about fifty hours, while the other had almost reached the turning point at the end of the fifteen hours that it was kept in the refrigerator. The most interesting part of this work is shown in

Table XVIII. It was found that though the refrigerator stood practically at 60 degrees, at the end of fifteen hours the milk ranged from 70 to 74 degrees. This milk was set in a shotgun can which offered more than ordinarily good opportunities for quick cooling. This work shows that cool temperatures of the air cannot be depended on to reduce the milk to a low temperature. As was said this work may apply to but a few producers for summer conditions, but it applies to many producers when it comes to winter conditions. Perhaps the majority of farm dairymen depend on the cold temperature of the air to cool the milk in the winter. During a few, a very few, of the coldest days this may be sufficient, and would, perhaps, be sufficient the greater part of the winter were it not for the way the consumer cares for the milk after it reaches him. A large part of the city residences are kept quite warm, and as no ice is used except in a very few cases the milk is more likely to sour during the winter than in the summer, as in the summer the milk is kept on ice. Now, the producer allows the milk to cool by standing in the air. It cools very slowly, and, unless the temperature is unusually cold, by the time the milk reaches such a temperature that no change will take place, it will be close to the souring point, and though it may taste and appear to be in perfect condition yet it will require but a short period at the temperature of the city dwelling houses to spoil. Because of this it is questionable if some measure should not be taken even in winter to cool the milk. Simply setting the milk in a tank of water that has been standing at the temperature of the air would be sufficient.

HOW TO COOL THE MILK.

In the foregoing pages the attempt has been made to show the need of keeping the milk at a comparatively low temperature and the particular need of getting it to this low temperature as soon as it is drawn. The best way of doing this and, with all, an economical way is to be considered. Where water alone is used for this purpose, it is of course to be had in unlimited quantities for the pumping. Where ice is at hand it may or may not be in unlimited quantities. Usually there is reason for being a little economical in its use.

As has been suggested, there are two general ways of cooling milk. The oldest and most common is to set the milk in a tank of water which may or may not have ice added to it. The other way is to run the milk over a cooler where the milk runs in a thin film over a metal surface which has its other surface in contact with cold water. Attention has been called to the fact that in setting the milk in ice water, several hours are required for the milk to reach a temperature below which rapid change may take place. In cooling by means of a cooler it is quite evident that the milk is cooled immediately, or as fast as it will run over the metal surface. If the rapidity of cooling was alone to be considered, it is evident that the cooler would be by far the more preferable. It remains to be seen whether they can be used economically.

There are two general styles of milk coolers on the market. One is made with a large body shaped much like a cone with its point cut off and in place of the point is a receiver with small holes punched around the edge. The milk is poured into this receiver and drops through the small holes onto the outside surface of the cone, and finally trickles down over this and drops into a bucket. On the inside of this cone is plenty of space for water and ice, and it would naturally be supposed that this would make a very efficient cooler. It is very much better than no cooler at all, but it has one very serious fault that does not become evident until the thermometer has been used in the cooled milk. The trouble lies in the fact that the water which touches the inside surface of the cooler soon becomes quite warm, notwithstanding the fact that a large quantity of ice may also be contained. When the contents of the cooler are kept constantly stirred up it does very well indeed. But where this apparatus is used there is a tendency to neglect the stirring as being too much trouble, with the result of poor work. It is worth repeating that for good results it would require the constant attention of one person for stirring the ice and water mixture. If the cooler is allowed to go longer than fifteen seconds without being stirred the milk running over it will be so warm that it will be above the danger point in temperature.

This cooler has another disadvantage in requiring ice. Of course, the milk could be cooled to some extent by filling the cooler with cold water, but this would become warm very quickly. There would be a constant change in the temperature, and it would require but a short period for it to become practically as warm as the milk. One of the best known coolers of this style was purchased by this Station purposely to test its merits and the points brought out are the results of actual tests made with the same.

In the other class of coolers the objection of the water becoming too warm to properly cool the milk is not found; for the water is flowing constantly through the apparatus and keeps constantly changing on the surface of the metal. This machine does have the disadvantage of requiring a constant water supply, which however is not as serious as it might seem. Two methods can be used for supplying this water. In many places a spring could be piped to where it was needed for cooling and connected directly. Another way would be to place a barrel on a platform above the cooler and have the bottom of the barrel connected with the cooler by a faucet and a short piece of rubber hose. This would require that the barrel be pumped full of fresh water just before beginning the milking, and it could be allowed to run slowly through the cooler, keeping up a constant stream during the milking. The rate of flow of milk and water could be regulated to the number of milkers. It might be necessary to refill the barrel if there was a big lot of milk to cool. But if a little ice could be added to the water, a very little water proportionately would be required Possibly the greatest advantage of this cooler would be in the fact that after it had been started it would need practically no attention. It will be shown how it is made to be an economical as well as an efficient way of cooling the milk.

Some work was done with this style of a cooler to determine how much water of varying temperatures was required to cool the milk to a reasonable temperature and also to test how near the temperature of the fresh water the milk could be brought. The result of this work is given in table XIX. The cooler used was of the Star pattern which seems to be the favorite of this class of coolers in this county.

TABLE XIX.

Temperatures of Water and Milk.

Proportion of Water.	Water.	Fresh Milk.	Cooled Milk.	Water after Cooling.
Two to one	50	98	57	68
Unlimited water	50	98	52	...
Two to one	44	98	52	60
Unlimited water	44	98	48	...
Equal quantities	35	98	55	80

In table XIX in the first column headed proportion of water the first trial given as "two to one" means that the faucet was opened so twice as much water would run through the cooler as there was milk to be cooled. When "unlimited water" was used the water was allowed to run through the cooler as fast as the pipe would carry, and the milk was run over the cooler as fast as it would run through the small perforations intended to feed the milk to the cooler as was the case in all the trials. There was about four times as much water used as milk cooled. In the last trial, equal quantities of water and milk run through and over the cooler. The milk in all trials was practically at body heat. In a few cases it was set in a tub of hot water to bring it to this temperature as it was not run over the cooler immediately after milking and had cooled down some.

The first and third trials show that where the water was used in the proportion of two of water to one of the milk, the milk was cooled to within seven degrees as cool as the water. In the third trial where the same conditions were observed, except that the water was at 44 degrees instead of 50, the milk was cooled to within eight degrees as cool as the water. In the two trials where unlimited water was used with water at 50 degrees the milk was cooled to 52 degrees and where the water was 44 degrees the milk was cooled to 48 degrees. A number of trials since that work was done have confirmed the results of the test made with unlimited water at 50 degrees, in that the milk was cooled to within two degrees as cold as the fresh water.

In the fifth and last trial given the water was at 35 degrees which would of course require that considerable ice be mixed with the supply of water. The cooled milk was at 55 degrees. This is a sufficiently low temperature for any milk to insure long keeping.

One of the most interesting results of this work is seen in the last column of the table, which gives the temperature of the water after it is run through the cooler. Where water in the proportion of two to one was used the waste water was eight degrees warmer than the cooled milk. To those who have used this style of cooler the reason for this is apparent. The cool water runs in at the bottom of the cooler and is forced up, the waste water running out at the top. The milk runs from the top of the cooler down. This brings the warm milk in contact with the warm water and the partially cooled milk in contact with the fresh and coldest water. Theoretically if the milk and water were run over and through the apparatus slow enough the cooled milk would be practically of the temperature of the fresh water and the waste water would be the temperature of the fresh milk. The practical benefit derived from this fact of the temperatures of the milk and water partially exchanging lies in the greater use of the temperature of the cold water. Where a can of warm milk is set in a tank of water containing no ice the milk is cooled only to an average of the temperature of the milk and water, quantity of both being considered. Thus, if the milk was 98 and the water was 50, and equal quantities of each were in the tank, the temperature of each would be 74 degrees, which would be entirely too warm for the milk to keep well, though the water had been at first below the temperature required for the keeping of the milk. If the water and milk were at 50 and 98 degrees respectively and there was twice as much water as milk in the tank the resulting temperature would be 66 degrees, still too warm for the milk to keep well. But with water at 50 degrees and the milk at 98 degrees and twice as much water as milk in a Star or similar cooler the milk would be cooled below 60 degrees which would insure good keeping qualities. The difference lies in the fact that the cooler makes better use of the water, and it does this from the fact that the milk is practically cooled when it comes in contact with the fresh cold water. In the foregoing discussions, no account is taken of the influences that outside temperature might have on the milk and water in the case where the milk was set in the water. At times this would be considerable, especially in hot weather, and would tend to make the final temperature of the water and milk still warmer and would consequently shorten the length of time that the milk would keep. Without a cooler of this style it is impossible to furnish good milk unless there is plenty of ice or a very cold running spring. With no ice and a cooler it is possible to keep milk in fine condition when there is plenty of water at a temperature of 60 degrees or under. At the temperature of 60 degrees considerable care would be needed, which will be discussed further along. With a cooler the milk can be kept better with much less expense than by simply setting it in a tank.

The foregoing discussion as applied to the setting of milk in a tank of water when ice is not used would apply also when ice is used. Ice is seldom put up in unlimited quantities and therefore it is quite necessary to be economical in its use. Setting cans of warm milk in a tank of ice water uses far too much ice as a relatively large quantity of it would melt in cooling the milk. Less ice would be required by cooling the milk first by means of a cooler and fresh well water, and then setting the cool milk in the ice water. By this treatment the ice would be melted from the influence of the temperature of the air only. This method of cooling and keeping the milk is ideal and would give almost perfect results.

In using these coolers the milk is at the same time aerated which, while it does no good in normal conditions, may do harm under wrong conditions. The best place for the cooler is out of doors or in a small room separate from the cow stable. If kept in the cow stables the cooling milk has so much surface exposed that it is likely to gather up any undesirable odor that is present in the air of the stable.

Another method of cooling milk quickly is by stirring the milk after it has been put in the tank of ice water. This would be very efficient if it were stirred continually until a low temperature was reached, but not one in a hundred persons, no matter how good their intentions, would continue the stirring for a sufficient length of time to insure the milk being cool. The only thing that can be depended on for this purpose is some sort of a cooler, something that gives good results with a minimum of watching and the only cooler that meets these qualifications is one that has a continuous stream of water flowing through it.

One thing which is very necessary when well water is used and when there is no ice is to have a double walled tank with a space of three inches between and some kind of material that is a poor conductor of heat should be packed into the space between the two walls. Sawdust or cut straw, chaff, or any such material would be good. Without this provision there will be times in the hot weather when it will be impossible to keep the temperature of the water and milk from running to a temperature that will make good keeping qualities impossible. Such a jacket and a tight cover to the tank would keep the water to within a very few degrees its original temperature. This arrangement would also result in a considerable saving of ice. It would be likely to require less than half the quantity of ice that would be necessary in a tank without this extra wall. A cover to a tank should never be used, however unless the milk is cooled before placing the cans in the water, and unless the tank is perfectly odorless. Otherwise, the milk may take up odors that will render it valueless.

One other plan that will aid in the keeping of milk is in the use of cans which will keep the milk from warming up to the best advantage. A few cans have been made with either wood or asbestos jackets, the jackets being intended to keep out the heat. For shipping milk to a city supply these cans have never come into practical use to any extent at least. Shippers can control the change in temperature of their milk to some extent by the choice of the size and shape of their cans. The greater the diameter of the can the slower will be the change in temperature. There is a limit to the size of the can that can be handled with care, but the can may be made short and of large diameter. Such cans undoubtedly would insure longer keeping of the milk by keeping it cooler during shipment. On the other hand these same cans tend towards slow cooling when the milk is cooled by setting it in tanks of water. These disadvantages would counter balance the advantages. The shape of the cans should be considered only when a cooler is employed in handling the milk.

Producers can further add to the keeping qualities of their milk by covering the cans with a wet blanket on the way from the farm to the shipping point. The wet blanket would help very much in keeping down the temperature of the cans, and where the drive is long this is an important item. This is one of the small things which costs nothing and is a very little extra trouble, but which helps considerably.

THE USE OF REFRIGERATORS.

As has been stated, a refrigerator is sometimes used for keeping milk, and the point was brought out that it did not do to set the warm milk into the refrigerator, expecting it to cool quickly enough to keep it from spoiling. However, when the milk is cooled before it is set in the refrigerator, this makes a very satisfactory way of keeping. It, of course, requires ice, but where ice would otherwise be used in keeping the water cold, perhaps the refrigerator would require no more than the water tank for the same result. Furthermore, where there is a refrigerator it could be used for household purposes to some extent, which would add to its value. Many of the large city dairies where a great deal of milk is handled use refrigerators instead of water tanks. This is especially the case where a refrigerating plant is run in connection with the dairy. In such a case a room can be kept cold with less expense than would be required for cooling tanks of water.

THE USE OF PRESERVATIVES.

It is not intended here to go into any extensive discussion on the use of preservatives in keeping milk. This subject was pretty thoroughly discussed by the writer in Bulletin No. 86 of this Station. The statement was made in that Bulletin that it was undoubtedly possible to furnish Baltimore with good milk without the use of preservatives, without an impractical amount of work and without excessive expense in caring for the milk. The work presented in the foregoing pages is proof of the feasibility of doing this, and it is the duty of the producer, the retailer and the city authorities to see that this is done. In the light of the present knowledge of the effect of preservatives, their use borders on the criminal. Were they necessary to keep the milk sweet until it reaches the consumer, there might be some excuse for employing them. They are not only unnecessary, however, but it is easy to get along without them, and their only necessity is in covering carelessness on the part of some one.

REFRIGERATOR CARS.

For shipping the milk supply of some of the Northern cities, the railroads use refrigerator cars. That this is a great improvement over the hauling of milk in the ordinary milk cars, there can be no doubt. The temperature of these cars, after a hot night when no ice is used, may be as high as 80 degrees, and it would not be putting it too high to say that on some hot afternoons the car might have a temperature of 95 degrees, for they are not built to keep out the heat. On the longest hauls into Baltimore it requires three hours for the milk to reach the city after it is put aboard the cars. This means that, including the length of time required for the producer to get his milk to the shipping point, the milk has to stand in this heat for as much as four hours. Even though the milk be as low as 40 degrees at starting, which it seldom is, the long time that it stands at this warm temperature would raise it above the point where it would change rapidly. By the use of refrigerator cars this change in temperature could be avoided and at no great expense to the railroad. The fact that such cars are being used for the northern cities is evidence that they could be used for Baltimore. Their need in the milk supply of Baltimore is greater than the need in the supply of Boston; and yet the railroads supply refrigerator cars for the latter city. Massachusetts is a State where either cold springs or cold well water can be found on every farm, while ice is plentiful and easily secured. But

Massachusetts is very particular in regard to the milk sold in its cities, and Boston is the most particular city in the State. The comparatively warm climate of Maryland is a reason why more care should be observed and more accommodations are necessarary than in Massachusetts.

The accommodation of refrigerator cars will never be obtained by the people of the State until it is demanded, and as is usually the case where railroads are concerned it will require the united and persistent demand of all concerned in the milk business. The city consumer would doubtless benefit by the use of refrigerator cars more than the producer, and the city authorities should be the first to start the effort for such cars.

It should not be considered that refrigerator cars would excuse the farmer from the best care of his milk, except possibly in one way. At the present time to warrant the milk arriving in the city at a temperature that will insure no change taking place it is necessary in the hottest weather to have the milk below 40 degrees when it leaves the farm. Were refrigerator cars in use the only opportunity that milk would have to increase in temperature would be on the road from the farm to the railroad. The long hot ride on the train would be eliminated, and because of this, a temperature of 50 degrees at the time the milk left the farm would get it to the city in perfect condition. Aside from this one condition, the producer would be under obligations to take as good care of his milk as though no refrigerator cars were in use.

During the summer of 1902 a few weeks were spent in one of the large Baltimore dairies, doing bacteriological work. This offered a very favorable opportunity to study a few of the points in connection with the condition of the milk supply. This particular dairy offered a little more money for its milk than the ruling price throughout the city. On the other hand, it wanted milk of more than average quality. The dairy itself was entirely up to date in all of its methods, and the manager was particularly desirous of supplying a good trade with a good article. Considering all of these points, it is rational to conclude that the milk bought by this dairy came from sources above the average in general conditions.

The points observed are given in Table XX. They included the temperature, percent. of acid and bacteriological counts of the old and new milk. This work, together with rides on a morning milk train, has rendered it possible to make a few deductions. The following is a table giving the facts in regard to the milk received at the Baltimore dairy:

TABLE XX.

	Germs per c. c., in Fresh Milk.		Germs per c. c. in Old Milk.		Temper't're when rec'd.		Acidity, Old Milk per cent.
Patron.	Maximum.	Minimum.	Maximum.	Minimum.	Fresh Milk	Old Milk	
A	61,000	23,000	13,000,000	4,800,000	69	68	....
B......	110,000	25,000	25,000,000	20,000,000	78	67	.19
C......... ...	1,000,000	100,000	5,600,000	2,400,000	..	62	.22
D.	100.000	30,000	350,000	120,000	60	55	.16
E	75,000	71,000	1,600,000	150,000	64	64	.17
F......	71,000	13,000	5,000,000	2,000,000	64	67	....
G	11,000	6,600	260,000	22,000	62	60	....
H...........	95,000	72,000	1,200,000	2,000,000	72	68	.21
I	24,000	23,000	200,000	100,000	71	63	....
J......	100,000	43.000	3,600,000	400,000	72	65	.19
K..........	260,000	64,000	2,000,000	600,000	70	65	....
L......	21,000	5,000	140,000	25,000	78	73	....

The headings of the different columns of Table XX explain themselves. The patrons are given by letter instead of by name, the need of this being evident. Many of the patrons of the dairy shipped twice a day, but only those are considered who shipped once a day. This work was mostly done in hot weather and shows the conditions of the milk under the worst conditions. From the bacterial content of the old and fresh milk and the temperature it is possible to make a safe guess as to about the way each patron's milk was treated. Judging from these it may be concluded that patron A kept his tinware and strainers clean, because, though he had evidently used no ice, the number of bacteria in the fresh milk was not great; and he evidently did not cool his milk quickly, because of the unusually large number of bacteria in the old milk. The temperatures of all these lots were taken on an unusually hot day which accounts for the milk being so warm in many cases.

Patron C evidently had ice, as his old milk was down to 62 degrees. But he kept things very dirty, as can be judged by the number of bacteria in the fresh milk. His milk was too sour to be accepted, or at least should not have been accepted, as it was very near the point where it could not be used. This is shown by the acid test of .22 percent. Patron D evidently did not keep things very clean, but he did cool his milk quickly and kept it cool by the use of ice, as is shown by the low temperatures of both the old and the new milk, and by the comparatively small number of bacteria in the old milk.

Patron G was evidently very clean, as is shown by the low number of bacteria in the fresh milk. He cooled his milk quickly and either had a cold spring or used some ice, as is shown by the small number of bacteria in the old milk, and the rather low temperature of both the old and new milk. He furnished milk that anyone would prefer. Patron I was fairly clean, and cooled his milk quickly. Patron K also cooled his milk quickly, but was dirty. He had no ice.

Patron L was the best of the lot. He kept things exceptionally clean. His milk was cooled as soon as it was milked, and though he had no ice, and his well evidently furnished water no lower than 60 degrees, he produced the best milk that came to the dairy. What he did could be done by anyone. It is one of the best evidences of the claims of the writer that it is entirely practical for any dairyman who lives within reasonable distance of the city, to furnish an exceptionally good article to his city buyer without the use of ice and with water which is not below 60 degrees.

In discussing the trip on a milk car, the one over the Western Maryland Road will be considered, as it will doubtless be about on an average with the other roads shipping milk, and it did not handle any of the milk going to the dairy where the work was done. The night before the trip was taken was a little cloudy and cool, which made the conditions a little more favorable than they usually are. The temperature of the old milk delivered to the train did not vary more than a couple of degrees from 60, except in two cases, where it was evident that ice had been used. It appeared very much as though most of the farmers had utilized running springs of perhaps a little below 60 degrees temperature. The region abounds in springs, and this makes ice unnecessary. It really was a matter of considerable surprise to find the milk running at such a uniform temperature. The morning's milk, except in a very few cases, was about as cool as the evening's, being below 70 degrees; and it must have been run over a cooler in some cases or set in cold water and stirred. In the few exceptions where the temperature was not so low, it was evident that the milk had received no cooling whatever, as it was up to about 80 degrees.

The cans, almost without exception, appeared to be very clean on the outside, but many of them seemed to be much the worse for wear and rust. On the other hand, the cans returned to the car were in miserable condition, such as to make one wonder how the farmer was ever able to get them thoroughly cleaned again. This is one thing in which the city authorities could and should take a hand, and force milk dealers to thoroughly wash every can before it is returned to the shipper. A few of the better dealers do this, and with the facilities which a dairy should have it would not be an expensive detail. A good milk supply will never be secured until it is done.

The greater part of the milk was hurried away from the car as soon as it arrived in Baltimore, and a pretty fair judgment of the class of the dairy could be formed by the promptness with which this detail was carried out. On the other hand some of the milk was left in the car until ten o'clock, or more than an hour after the car arrived. How this milk would be fit to use after such treatment, especially in very hot weather, can be explained in only one way, and that would be by the use of an alkali to reduce the acidity and a liberal use of preservative to prevent further change in the milk.

The producer is not the only one who is to be criticised for the poor quality of much of the milk sold. The city dealer comes in for as much or more blame. They are as careless as the farmer or more so. And instead of setting a good example to the farmer they set him a poor one by returning cans that it is almost impossible to wash clean. The city dealer knows the need of good milk, and the problem of its production should come home to him with sufficient force to insure his adopting good methods.

USE OF THE ACID TEST.

Milk dealers are at a loss at times to know what milk should be accepted and what should not. A carefully trained nose can detect any very slight undesirable odor in the milk, and, of course, can detect when the milk starts to turn sour or has become so sour as to be unfit for use. But souring is something that comes on gradually, and there is a stage in its progress that cannot be detected by the sense of smell or taste. Milk which is in this stage would, of course, be accepted, as the receiver could not tell that it was turning. But perhaps within half an hour after it had been accepted the souring would reach a point where it could be tasted and this would render the milk unfit for use. It would then be a loss to the buyer. Moreover, if it was cooled and delivered to the consumer before it had reached the point where the acid taste was perceptable, it would sour as soon as it met the unfavorable condition in the hands of the consumer, and would likely be more of a loss to the dealer than though it had soured before delivery.

Some way to detect when milk first commences to sour should be welcomed and used by all milk buyers if it is simple and practical, and there is such a method within easy reach of every milk handler. To understand the use of an acid test it is necessary to understand, to some extent, the nature of the acidity of milk. Milk as it comes fresh from the cow is neutral. That is, it is neither alkaline nor acid. After it sits for a couple of hours the milk appears to be acid when tested by chemical means. This acidity is not due to dirt or any controllable conditions, but is natural to all milk. It is evidently caused in part by the carbonic acid in the milk and by some of the mineral salts natural to the milk. This acidity remains practically permanent.

After the milk stands for a time, if allowed to remain warm, certain kinds of bacteria commence to grow, that change the milk sugar into lactic acid. It is this lactic acid that gives the milk the sour taste that renders it unpalatable, and finally thickens it. These bacteria are very few in number at first, and while they are manufacturing lactic acid all of the time, it is not until there are millions of the germs that enough lactic acid is manufactured to make a change in the milk which is perceptible even where chemical means are employed for detecting it. But when it is remembered that these germs multiply in numbers exceedingly rapid, it can be seen at once that after the first slight perceptible change takes place in the milk, the acidity increases with continually accelerated rapidity until the milk is made unfit for use. This change can be entirely checked by the use of cold, but it commences again as soon as the milk is brought under favorable conditions. It is desirable then to be able to determine just when the milk first commences to change owing to the lactic acid. For as soon as the acidity of the milk commences to increase owing to the lactic acid, it is really poor material for any dairyman to handle.

Unfortunately, it is impossible to tell just when this is in the regular course of taking in milk for this reason. The natural acidity of the milk owing to the salts present, has been mentioned. Unfortunately, this natural acidity varies in different lots of milk. In one lot of milk the acidity may be as low as .12 per cent., while in another it may be .18 percent., or even higher. In view of this fact the only possible way to adjust the matter is to adopt some standard of acidity beyond which the milk cannot go without being rejected. The only just way is to put this standard as high as there is any likelihood that the mixed milk of a herd may reach from natural causes. No definite work has ever been done to determine what this standard should be, but .2 percent. has been suggested, and as far as it has been possible to determine at this Station it is sufficiently high to meet all requirements.

To determine the acidity of milk, decinormal solution of sodium is used; a measured quantity of milk is put in a cup either porcelain or glass. A few drops of phenolthalein is put into the milk as an indicator, and the decinormal solution is dropped in from a graduated burette until the milk commences to turn a very faint pink color. This pink color comes when all the acid in the milk has been neutralized by the decinormal solution. By knowing the quantity of milk and the quantity of decinormal solution required to neutralize the acid in the milk, it is an easy matter to calculate the percent. of acid.

The method in detail as adopted at this Station and a very easy and practical one was as follows: The decinormal solution was held in a long burette which was fixed in a standard, the burette being graduated into one-tenth cubic centimeter and having a pinch cock for dropping attached. The regular pipette used for measuring milk in testing was used for measuring the milk for the acid test and 17.5 c. c. of milk or 18 grams of milk was put into a glass beaker, a few drops of the phenolthalein was added and then the decinormal solution was dropped into the milk until it showed a faint pink color, the milk being kept constantly stirred while the solution was being dropped in. The amount of decinormal solution required was read off from the graduated cylinder and this divided by two gave the percent. of acidity of the milk. For instance if it required four c. c. of the decinormal solution, this divided by two would give .2 per cent. as the acidity. If it required 3.8 c. c. the acidity would be .19 per cent.

In using this method the required 17.5 c. c. of milk might be put in the cup and four c. c. of solution put in and shaken up. If it turned the milk pink it could be accepted, if it did not turn it pink it could be at once taken for granted that the milk was too sour to accept. Milk commences to taste sour to a trained taste when it has .26 per cent. of acid, and the standard of .2 per cent. would leave .06 of acid to develop before the milk became unfit for use. It would be better if a still smaller per cent. of acidity could be adopted as a standard as the margin of .06 means a very few hours keeping if the milk is held at 60 degrees. It may be that after this question of the acidity of the mixed milk of a herd has been investigated it will be possible to set a lower per cent. as a standard. Possibly .18 per cent. or still lower.

The chemicals used in an acid test would be very cheap and could be secured ready prepared from any chemical house. The other apparatus need not cost more than two dollars. The buyer might save this cost of the outfit several times over in one hot day, to say nothing of being able to raise the standard of his milk. The time required for making a test might be one-fourth minute when the operator became acquainted with it. There is every reason why some such method should be adopted by every retail milk buyer.

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EXPERIMENTS UPON THE USE OF POTASH AS A FERTILIZER.

BY H. J. PATTERSON.

INTRODUCTION.

The considerations which prompted the planning of the experiments upon which a report of progress is given in this Bulletin, had for their object the solving of some of the underlying principles connected with the use of potash fertilizers so as to ultimately arrive at some conclusions which would have a broad and universal application throughout the Middle Atlantic States and other places with similar surroundings. These experiments were *not* conducted with the idea of having what is popularly designated as a soil test of this particular class of lands, and whatever the results show of this nature will be given a secondary consideration.

Before proceeding with the details of the plans of the experiments and the discussion of the results, it will probably be well to devote a little space to a general description and consideration of the subject of potash manures, the forms in which we find potash and the various sources of the same, and give a general historical sketch of the use of potash in agriculture.

HISTORICAL.

There is no definite record as to the time when potash was first used as a manure; but no doubt that part of the value which attended the use of lime † was due to its action in liberating and making potash available. From the writings of Young and Chateauvieux (1788 to 1812) we gather that the farmers in the neighborhood of Vesuvius recognized the value of the ashes, which the volcano poured forth from time to time, as a fertilizer to the land; and this fertilizing value was no doubt in a large measure due to the potash which the ashes contained, especially from the fact that the classes of crops which they grew are relatively heavy feeders on potash. Another early reference which would seem to be a recognition of the value of potash as a manure was in connection with the practices of the Flemish farmers, during the eighteenth century, of burning the rape, a crop which they grew largely for its seed, pods and straw for their ashes, which they chiefly used as a top dressing upon clover. These ashes were so highly prized for this purpose that they brought three times the price of all other sorts of manure used at that time.

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† According to Pliny, lime was probably used 200 to 300 years B C.

The ashes of the Saltworth, called *Barilla*, which was sent, near the beginning of the nineteenth century, exclusively into commerce from Sicily and the east coast of Spain, for use as a fertilizer, contained about five per cent. potash, and part of their value in agriculture was no doubt due to this element.

Some of the good results attending the old English custom as usually practiced, of burning land, no doubt was due to the potash remaining in the ash residue.

The early American settlers observed that the land upon which brush and trees had been burned had an increased productiveness.

All of these observations and data would simply show that the first potash applied to land for fertilizing purposes was in the form of ashes; yet it was done without attributing the value to any one element. It was not until after the advent of agricultural chemistry and the relation of the mineral matter of soils and plants as pointed out first by Saussure, in 1804, and then further established and shown to be essential by the work of Sir Humphrey Davy, as is evidenced by his statements in *Elements of Agricultural Chemistry*, published in London in 1814, that potash was really recognized as an essential to plants, and that certain manures owed their value to this element. Springel, in his *Theory of Manuring*, published in 1839, was the second to express an opinion to the same effect.

The researches of Justus Von Liebig served to show the necessity of potash to plants and it was through the publication of his results that the value of this element became generally known.

For many years the only sources of potash was ashes of plants and the nitrate of potash (saltpeter or niter) found in caves, but this latter was generally so much in demand for making gunpowder and in other arts that its price was such as to prevent its extensive use in agriculture.

In 1857 the Prussian Government made borings near the Harz Mountains for rock salt and found great quantities at Stassfurt about 1080 feet below the surface. Immediately above this rock salt are deposits of various potash and magnesia minerals which at first were thought to have but little value and were thrown away; but very soon after this discovery the results of Liebig's investigations became generally known and the value of potash as a fertilizer recognized. This offered a market for these potash minerals and caused a factory for the refining of them to be established in 1861.

THE ROLE OF POTASH IN PLANTS.

Essential for the Formation of Starch and Protein.

It has been firmly established that potash is of paramount importance for the proper functions of every living cell. Potash plays an important part in the organization of starch and also serves as a means for enabling starch to move from one part of the plant to another. It has been proven that these functions of potash are not performed because of its alkalinity but are due to some other undiscovered virtue; at all events, none of the other alkalies are competent to take its place.

In green plants the potash is concerned not only in the synthesis of carbohydrates but also in that of protein bodies, since not only is there an increase of potassium salts in such parts of green plants as are developing rapidly and consequently forming large amounts of protein, but most fungi are found to require potassium salts for the production of protein. In the absence of potash plants will not grow and neither starch nor protein will form or move in them no matter how much of the allied alkalies, (sodium lithium, caesium or rubidium) may be offered to them.

The juices of plants which are noticeably sour, such as the leaves of sorrel, stalks of rhubarb, juices of lemon, apple, gooseberries, grapes and the like, commonly contain an organic acid salt of potash.

The physiological role which potash exerts in connection with plant growth seems to be in a measure due to the peculiar chemical condensation properties possessed by this element over other elements of its group; as pointed out and discussed at length by Dr. O. Loew, in Bulletin No. 18, p. 21–28. The Physiological Role of Mineral Nutrients, published by the Division of Vegetable Pathology, U. S. Department of Agriculture. Experiments conducted by Helreigel have shown very clearly that a certain amount of potash was necessary in order that perfect barley could be produced. The so-called clover sickness of soils has in some cases been traced to a deficiency of potash.

SODA AS A SUBSTITUTE FOR POTASH.

There has been much said on this subject and some people have made claims that soda can replace potash in the plant; but careful experiments have proven beyond a doubt that potash is essential to plant growth and is never absent in any part of the plant, generally present in considerable quantities. Soda has been shown not to be essential in all cases and is often entirely absent from the grain and tuber of plants. Even in cases where it has seemed indispensible a very moderate amount answered the requirements. There have been a few cases where soda seemed to replace potash to a slight extent, but in such instances the excessive feeding upon soda has been either mechanical or accidental. Observations upon salt marsh plants have shown that potash was essential and that they responded to potash fertilization. In cases where increased yields and general good results have followed the application of common salt (sodium chloride) the good results have been due to its action as an indirect fertilizer by rendering the plant foods already in the soil available and gives beneficial effects upon the physical condition of the soil and cannot be attributable to the soda being used as a food by the crop.

QUANTITY OF POTASH ANNUALLY REMOVED FROM MARYLAND FARMS.

In order to convey some idea of the great drain of potash from the farms of Maryland the figures in Table I have been compiled, showing that which is removed by the staple crops. Though large as these figures may seem, yet they represent but a part of what is taking place. The amount removed by over seven million dollars worth of truck crops, small fruits, orchard fruits and forest products annually sold from Maryland is not accounted for in the table. Again, the live stock, poultry and eggs carry considerable potash with them. The total amount of potash removed by the crops, as exhibited in Table I of 62,673,547 pounds would require if it were to be replaced over 62 thousand tons of standard

Muriate of Potash, or 250 thousand tons of kainit. This would mean an expenditure of over two million dollars annually for potash alone.

TABLE I.

The Approximate Quantity of Potash Removed from Maryland Farms.

(Compiled from data given in 12th U. S. Census.)

	Acres.	Value of Product.	Quantity. Bushels.	Pounds of Crop.	Per cent. Potash.	Pounds of Potash.
Corn grain	658,010	$7,462,594	19,766,510	1,107,924,560	0.40	4,431,698
Corn fodder				2,215,849,120	1.40	31,021,887
Wheat	634,446	6,484,088	9,671,800	580,308,000	0.61	3,539,878
Wheat straw				986,523,600	0.51	5,031,270
Oats	44,625	340,475	1,109,560	35,505,920	0.62	220,136
Oat straw				60,360,064	1.24	748,464
Barley	1,515	18,776	42,560	2,042,880	0.48	9,805
Barley straw				3,342,141	2.09	69,850
Rye	21,621	141,433	279,550	15,654,800	0.54	84,535
Rye straw				26,613,160	0.79	210,243
Buckwheat	8,047	58,623	115,950	5,565,600	0.21	11,687
Buckwheat straw				9,461,520	2.42	228,968
Kafir corn	1	3	6		0.42	
Flaxseed	3	41	50	2,800	1.37	38
Clover seed		45,761	10,484	629,040	1.29	8,114
Grass seed		1,019	616	8,624		
Hay & forage (tons)	374,848	4,709,072	507,042	1,014,084,000	1.55	15,718,302
Tobacco (lbs.)	42,911	1,438,169	24,589,480	24,589,480	3.81	936,859
Hops (lbs.)	(*)	21	230	230	2.30	5
Broom corn (lbs.)	93	1,658	35,910	35,910		
Peanuts	7	137	143		0.88	
Dry beans	605	7,038	4,754	285,240	1.26	3,294
Dry peas	947	12,725	12,459	747,440	1.01	7,549
Potatoes	26,472	1,020,003	1,991,357	119,481,540	0.29	346,496
Sweet potatoes	6,469	317,462	677,848	40,670,880	0.37	40,673
Onions	503	33,308	56,148	3,368,880	0.10	3,368
Miscel. vegetables	99,900	3,944,959				
Maple sugar (lbs.)		20,561	264,160	264,160		
Maple syrup (gals.)		3,622	5,825			
Sorghum cane (tons)	63	314	† 91	182,000		
Sorghum s'r'p (gals.)		1,559	4,058			
Grapes (cental)	‡ 775	§ 43,282	16,859		0.27	
Orchard fruits	91,073	‖ 1,266,047				
Tropical fruits		2				
Nuts		2,055				
Forest products		1,170,362				
Flowers and plants	174	355,862				
Small fruits	17,516	1,181,054				
Seeds	54	7,183				
Nursery products	1,275	123,474				
Willows (lbs.)	23	2,838	284,000	284,000		
Miscellaneous		1,389				
Total	2,031,976	$30,216,969				62,673,547

* Less than one acre.
† Sold as cane.
‡ Estimated from number of vines or trees.
§ Including value of raisins, wine, etc.
‖ Including value of cider, vinegar, etc.

The figures given in Table I show something as to what is taking place in the State at large, but the figures are so large that they are somewhat bewildering; so in order to present an idea of the amount of exhaustion of potash by crops in a little different way and upon a basis which is more easily applicable to the cropping on each farm, calculations have been made of the quantity of potash removed from one acre by a fair yield of some of the commoner products. These figures are presented in Table II.

TABLE II.

Approximate quantity of Potash in the Product of One Acre of Sundry Farm Crops.

Estimated Crop.	Potash lbs.	Value of Potash cts.	Equivalent in Muriate of Potash. lbs.
Corn, 50 bushels	10.4	52	21
Oats, 40 bushels	7.9	39	16
Wheat, 25 bushels	7.8	39	16
Potatoes, 150 bushels	52.2	261	104
Tobacco, 800 pounds	32.5	162	65
Tomatoes, 10 tons	53.8	269	107
Clover Hay, 2 tons	74.4	372	149
Timothy Hay, 2 tons	81.0	405	162
Wheat Straw, 1¼ tons	15.7	78	31
Silage Fodder Corn, 15 tons	111.0	555	222

The figures given in the Table are not intended to show the amount of potash needed for the growth of the whole plant or crop, but simply what would be removed in the parts which are generally sold.

Though these figures in some cases seem very small, in fact almost insignificant, yet when the fact is considered that these amounts of potash are being removed annually and under some systems oftener, and that most of the lands have been under cultivation for a considerable length of time it will be realized that even these small amounts represent a great drain upon the land when multiplied by 10, 20, 50 and even 100 or more crops. Anyone interested to calculate out the amount of potash removed by any particular crop can obtain the potash content of most agricultural products by referring to Table VI in Bulletin No. 84 of this Station.

RELATIVE QUANTITY OF POTASH IN DIFFERENT PARTS OF PLANTS.

In cereal crops about four times as much potash is removed in the straw as in the grain, while in peas and beans and other crops of that kind the straw contains about twice as much as the seed. This is an important fact to be considered in the use and saving of the straw for feeding and manure.

THE ORIGIN OF POTASH IN SOILS.

From what has been said it is seen that potash is absolutely necessary for the growth of plants. Indeed, there must be a fairly large supply of this element within reach in order that plants may prosper.

There is, naturally, a good deal of potash in the soil, as follows necessarily from the fact of its occurrence in the ashes of plants. The potash naturally present in the soil in common with its other mineral constituents, has been derived from the decomposition of the original rocks. The soils which are richest in potash are those which have been derived from rock rich in potash-feldspar, but much potash is also derived from mica, glauconite, and other minerals, and even limestones furnish a small amount. In original rocks the potash is chiefly united with silica in more or less complex unions and wholly insoluble in water. In the decomposition of these rocks some of the potash is rendered soluble and lost by the leaching produced by heavy rains, but with the remaining portion there is not much chemical change, so that the potash is still held in the insoluble state, but nevertheless so finely divided and in such a mechanical condition as to yield gradually to the demands of the growing plants.

AMOUNT OF POTASH IN ROCKS.

As has already been noted, soils derive their potash from the decomposition of rocks. The rocks supplying the most potash to soils are those which contain considerable of the potash-feldspars. The rocks containing this mineral are widely distributed. Feldspar itself is chiefly a silicate of alumina associated with the silicates of potash, sodium or calcium. The predominating alkali is either potash or soda. Either of these alkalies may predominate, but there will always be found associated a small amount of the other. The amount of potash in feldspar varies from 5 to 17 per cent. Some of the best are those found at French Creek Mines, Warwick, Pa., which contain about 16 per cent. potash; at Magnet Cove, Arkansas, 15.6 per cent. potash and at Leverett, Mass., 12.2 per cent. potash. These potash feldspars contain as much potash as the kainite of commerce but unfortunately their potash is insoluble in water and there is no economical means of rendering the potash available.

Many of the volcanic rocks are rich in potash and as they decompose readily, have been used as a source of potash. Mica contains from 3 to 5 per cent. potash; clay slate 1 to 4 per cent.; basalt ¾ to 3 per cent. These are all double silicates. The "green sand" marls which are widely distributed along the Atlantic coast and found in extensive deposits throughout the Eastern Shore and Southern Maryland mixed to a greater or less extent with the shell marls contains a mineral called glauconite, which is rich in potash. The marls in Maryland vary from nothing to nearly 5 per cent. potash. When these marls contain considerable shells they can be burned for lime and at the same time this process will cause the potash to become available to crops more quickly.

THE QUANTITY AND DISTRIBUTION OF POTASH IN SOILS.

From what has been said as to the origin of soils and the variation in the composition of the potash minerals, it is evident that soils will vary considerably as to their richness in potash.

The typical soils of Maryland, as analyzed and reported upon in Maryland Station Bulletin No. 70, show a variation of one-tenth to four per cent. of potash.

An acre of soil, such as was used for the potash experiments reported upon in this Bulletin, weighed, to the depth of six inches, about 1,812,964 pounds, which, with a soil containing about one per cent. of potash, would mean that such a soil contained about 18,000 pounds, or 9 tons, of actual potash. Such a soil would have enough potash in the six inches of surface soil, alone, to grow crops of wheat of 25 bushels each for over 700 years before the potash would be entirely exhausted.

The relative quantity of potash found in surface and sub-soil varies in different formations, and also with the character of cropping and cultivation which has been pursued, but generally there is more in the subsoil than in the surface soil. This fact is important, as it shows the necessity for adopting such a system of culture and cropping as will contribute towards bringing some of the potash up to the upper layers of soil.

CONDITION OR STATE OF THE POTASHES IN THE SOIL.

Potash exists naturally in soils in a condition which is insoluble in water, and even the very soluble potash salts which are supplied in commercial fertilizers sooner or later form combinations in the soil which are no longer entirely soluble in water. It is probable that most of the potash in soils which is immediately available to crops exists in combinations commonly designated as hydrated double silicates, or in that of double humates. In very rich soils and in those recently fertilized, some soluble potash salts will be found clinging to particles of soil by adhesion. While a small amount of the potash silicates and humates are soluble in water, yet they are chiefly made available to crops through the agency of the carbonic acid waters of the soil, and through the agency of acid solutions which exude from the roots of plants. These facts emphasize the need for organic matter in soils so as to furnish the humates and to charge the soil waters with carbonic acid.

CONDITIONS AFFECTING THE AVAILABILITY OF POTASH.

We have already seen that the form or combination in which the potash exists has much to do with its availability. The degree of fineness of the soil particles also affects its solubility, and hence its availability to plants. The clay, therefore, generally possesses the highest degree of solubility and decreases with the coarseness of the particles. These coarse particles will be gradually broken up and disintegrated by the action of the elements, and thus the plant-food will become gradually available in the course of years.

Thus, it is seen that Nature guards her storehouse of potash from rapid consumption and yields up only limited portions each year. This is also true in respect to the other plant-foods. This seems to be a very wise provision, for no doubt, should science discover methods of rendering the plant-foods available rapidly and in unlimited quantities, that aggressive agriculturists would not hesitate to take advantage of the opportunity and consume it at once.

However, there are some methods which farmers can use to make the potash stores of the soil more readily available to crops, the chief of which is the growing of crops which have a great ability to feed on elements which are unavailable to most plants and this may be termed digestion of plant-food. By filling the lands full of organic matter and thus aid in the forming of humates and charging the soil-waters with carbonic water. And also by applying such materials as lime, phosphates, salt, etc., that will facilitate the formation of the double silicates. With potash, as well as with other fertilizing materials, it is necessary, in addition to what has already been said, to always provide for good drainage and then to use good cultural methods so as to insure the proper aeration of the soil.

GENERAL CONDITIONS INDICATING THE NEED OF POTASH.

In general the fertility of the land is determined by the least abundant fertilizing principal, not by the most abundant. It is more important for plants to be furnished a well-balanced ration than it is for animals; for, in fact, within very narrow limits, a plant will consume only a balanced ration and when the supply of materials necessary for balancing its ration are exhausted it does not attempt to substitute anything else, but simply stops growing. Consequently, it is only when the other needed plant-foods are present in the proper proportions that satisfactory results can be expected to attend the application of potash or any other fertilizer. Numerous experiments in this country have shown the force of these statements and that there was no use in expecting one pound of plant-food to do the work of two pounds. This primary condition is frequently neglected, partially owing to indifference and partially because of the difficulties attending the determination of the requirements of the soil. Whether a given soil may require the addition of potash to arrive at its maximum fertility may be determined by experiment, or, in a measure, by analysis.

When the total amount of potash as determined by analysis falls below one-tenth of a per cent. it is a fairly sure indication of the need of potash. Nevertheless, soils which show plenty of potash by analysis may still be deficient in this element as it may be in an unavailable condition. In such case it will be necessary to adopt means of rendering the amount present available and supplementing it by appplications until this condition is arrived at. The general character and origin of the soil give some indications as to the potash requirements. Reclaimed marshes, vegetable soils, light sandy soil and soils of water or "drift" formation are most always uniformly deficient in potash. A mechanical examination of soils also gives some indication of their richness in potash; since as the content of clay increases there is generally a corresponding increase in potash, due to the fact that both clay and potash are derived from the decomposition and breaking down of silicates.

Certain phases or kinds of so-called "clover sickness" in soils is due to an insufficient supply of potash. The kind of cropping to which soils have been extensively subjected also gives some indication as to the probable deficiency of potash as for instance, land which has grown many crops of tobacco, potatoes or beets.

HOW FAR CAN CHEMICAL ANALYSIS OF SOIL INDICATE POTASH REQUIREMENTS?

The chemical determination of the amount of potash in a soil is useful in showing what course should be pursued in the matter of cultivation and fertilizers. If a soil shows a considerable percentage of potash by analysis, it indicates pretty clearly the probable course which should be pursued. In the first place, there would probably be no need of artificial applications of potash, yet if the plants showed a deficiency in potash, then it would be pretty evident that some methods of culture and applications should be made which would render the existing potash available to the crops. Lime, plaster and dissolved phosphates are agencies which will aid in making potash available, and such crops as peas, beans, clover and vetch can feed on potash, which would be unavailable to wheat, corn and timothy. Fall plowing and other cultural methods are aids in the decomposition of potash minerals.

Considerable effort has been made to determine the difference between available and unavailable potash, but nothing very satisfactory has been arrived at. Experiments of some German investigators seem to indicate that for most cereals the soil should contain at least two-tenths of 1 per cent. of potash soluble in 10 per cent. hydrochloric acid. Hilgard, of California, as a result of a great deal of work on the soils of the South and West, gives the following figures as the amounts which should be soluble in strong hydrochloric acid in soils of various characters:

Potash:	In sandy soils of great depth may be	less than 0.1	per cent.
	In sandy loams	0.3 to 0.1	"
	In loams	0.45 to 0.3	"
	In heavy clays and clay loams	0.80 to 0.45	"

This Station has made considerable study of this question upon typical soil samples, a report of which is contained in Bulletin No. 70. The following are some of the conclusions arrived at:

Upon comparing our results with the conclusions of Hilgard, with productive, unfertilized soils of other States, and with one another, some very interesting points are noticeable. Judged by Hilgard's standards, the Columbia, Gneiss, Serpentine, Gabbro and Potomac clays are deficient in potash. Compared with the strong Western soils, the amounts of potash removed from our heaviest and best soils are considerably above the minimum; those that are below are the Columbia, Gneiss, Serpentine and Potomac clays, or the same soils that are below the Hilgard standard. The total amount of potash contained even in the poorer soils is so large as to suggest that it may be well worth the effort to render some of the reserve store available rather than to apply potassic manures indiscriminately.

When a weak acid solution was used, fifth normal (about 7 per cent.), the amount of potash dissolved is from 0.0062 per cent., from the corn and wheat soils of Southern Maryland, to 0.024 per cent. in the Columbia corn and wheat soils of the Eastern Shore. These percentages are equal to about 190 and 700 pounds, respectively, in an acre to the depth of one foot. The amount of potash soluble in this dilute acid in one acre one foot deep is about as follows:

TABLE III.

	Pounds.
Columbia, truck—southern Maryland	300
Columbia, truck—Eastern Shore	250
Chesapeake, tobacco	425
Chesapeake, corn, wheat	300
Columbia, corn, wheat—southern Maryland	190
Columbia, corn, wheat—Eastern Shore	700
Hudson River shale	475
Gneiss	325
Gabbro	400
Helderberg limestone	650
Catskill sandstone	510
Triassic sandstone	450
Trenton limestone	350
Cambrian sandstone	480
Serpentine	460

From the crop history of the soils and these figures, what conclusions can we draw as to the supply of potash in the several formations? It has been stated that general practical experience shows under present conditions the various truck soils and the Columbia corn and wheat soils of Southern Maryland are benefitted by applications of potash. It is problematical whether the productiveness of Gneiss, Gabbro, Serpentine and Potomac clays are economically increased by application of potash. It is safe to say that in general no economic benefit follows the use of potash on the other formations. If we regard the truck and the Columbia corn and wheat soils of Southern Maryland as the only soils deficient in potash, we must conclude that when a soil shows less than 300 pounds of potash per acre foot, in fifth normal acid, it needs potash; if we regard as deficient the Gneiss, Gabbro, Serpentine and Potomac clays, we must say that soils showing by this method less than 460 pounds of soluble potash, need potash. This would include also the Triassic sandstone, Trenton limestone, Chesapeake wheat and Chesapeake tobacco; all of which are certainly capable, under proper conditions, of supplying all the potash needed by ordinary crops. The conclusion is forced upon us that so far as potash is concerned the method shows nothing definitely that has not been shown by the strong hydrochloric acid method and by experience. It presents additional, though not strong evidence, that all soils of the State (except the truck and the Columbia corn and wheat) are well supplied with potash.

These results will be specially useful for farmers in connection with a study of the soil areas indicated on the soil maps which have been issued of some counties.

KINDS AND SOURCES OF POTASH FERTILIZERS.

From the facts which have been presented it is very evident that potash is one of the essential constituents of plants and that while some soils are naturally deficient in this element, others are becoming so through the system of cultivation and cropping to which they are being subjected. These two conditions make it necessary to have recourse to the application of potash to a greater or less extent in most agricultural sections. In order to use potash intelligently when needed it is desirable to know something of the nature of the different sources available for furnishing this supply; so before taking up the experiments conducted with various potash fertilizers a little space will be given to a detailed description of the principal potash manures on the market.

GERMAN POTASH SALTS.

Most all of the potash used for fertilizing purposes not only in this country, but in the world, comes from the Stassfurt mines in Germany and are properly designated as German Potash Salts. There are a variety of these salts varying in composition and amount of potash which they furnish. A brief history of the origin and a description of these salts will be given in the following pages.

ORIGIN OF THE STASSFURT POTASH DEPOSITS.

The following is the description of the origin of this deposit as given by the German Kali Works and published in the pamphlet entitled, "Stassfurt Industry."

"The Stassfurt salt and potash beds were formed or deposited in ancient, geologic times. Long before history begins these minerals were laid in place by the evaporation of sea water confined in lakes, which, somewhat like the Dead Sea and Baikal Lake, were without outlet. These were connected with the ocean by channels, ordinarily dry, but through which the sea water was forced at times by great storms and tides. In this way fresh supplies of salt were received into these lakes, and, as the climate of Europe was tropical during this formative period, the surface evaporation of the water was exceedingly rapid. As the water levels of these lakes thus sank, fresh supplies pushed in from the sea, holding in solution then, as now, many salts. Evaporation carries off only pure water, so, in course of time, as more salts were entering the lakes and none going out, the water became saturated with salts until those least soluble in water began to separate from the more soluble ones and deposit themselves in more or less uniform strata. By such continued evaporation and ever increasing concentration these immense layers of rock salt and anhydrite (sulphate of lime) were formed.

As the rock salt separated and the concentration became greater, other more soluble salts began to deposit and cover it, layer upon layer, up through the mineral polyhalit, which is composed of sulphate of lime, potash and magnesia; kieserit, which is composed of magnesia; and the "potash region," the stratum of carnallit, a compound of chlorides of potassium and magnesium. This last-named stratum ranges from 50 to 130 feet in thickness, and supplies the crude salts from which the most important and concentrated potash salts are refined.

From thus referring to strata it does not follow that these deposits are in smooth, clear-cut layers. From time to time, as additional water came in from the sea, the lake water became so diluted that precipitation was arrested to a certain extent and, later, had to commence again; thus anhydrite is found in the rock salt strata, and seams of rock salt in the polyhalit and other upper layers. Potash and magnesia salts are the most soluble, and, therefore, naturally found at the tops of the deposits.

Had these deposits been exposed to the action of rain water, they would have been dissolved, but they were protected during geologic changes by a covering of "salt clay," impervious to water. Above this salt-clay roof occurs a deposit of anhydrite; beneath, a second deposit of rock salt—a later formation, and probably of recent origin, geologically speaking. The depth of the Stassfurt salt deposit, from the top of the upper to the bottom of the lowest stratum, is some 5,000 feet. The beds underlie the extensive country reaching approximately to Thuringia on the south, to Hanover on the west and to Mecklenburg on the north.

These deposits, in the order of their placing, follow well-understood physical and chemical laws; and yet local conditions and geologic disturbances fixed the relative positions of strata and account for more or less apparent disturbances. At a few places, surface water found access through cracks or fissures, and either carried away potash salts or changed them into secondary products; from which action in the upper strata occur beds of kainit, sylvanit, hartsalz, and other compounds of less importance.

This description, somewhat tedious to unscientific readers, becomes of surpassing interest when the enormous importance of the formation is considered. But for these peculiar conditions at Stassfurt (conditions generally termed accidental) these potash deposits could not have been formed; and vast tracts of agricultural lands, now made fertile and productive by the use of potash from this inexhaustible store, would be sterile and barren for want of it. There is no question as to this scientific fact, and thoughtful readers may well again peruse the story of these wonderful deposits and question whether a formation—all but a creation—of such importance to the human race, can be considered a mere chance—a simple accident of nature.

DESCRIPTION OF THE POTASH SALTS:

Natural Products of the Mines.

Salt is the chemical name for a compound composed of an acid joined to, or combined with, a base. For example, burnt lime is a base, which in combination with sulphuric acid, forms a salt called sulphate of lime; similarly the base sodium combined with hydrochloric acid forms the salt sodium chloride. This last is the compound to which, popularly, the word "salt" is applied, for sodium chloride is our common table salt; but chemically the term is a general name for compounds produced as described above. The Stassfurt deposits contain various salts and combinations of salts, many of which contain little or no potash. The following list gives those most important as potash producers, with their mineral names and chemical formulæ:

Carnallit	KCl, $MgCl_2$, $6H_2O$.
Kainit	K_2SO_4, $MgSO_4$, $MgCl_2$, $6H_2O$.
Sylvinit	KCl, $NaCl$, K_2SO_4, $MgSO_4$, $MgCl_2$, $6H_2O$.
Hartsalz	KCl, $NaCl$, $MgSO_4$, H_2O.

Upwards of thirty different minerals are found in the Stassfurt deposits, of which some twelve contain more or less potash. The four above named yield the main supply of commercial potash, and of these the first three are most important.

Kainit.

The most important of the natural salts of potash for fertilizing purposes is the mixture known as kainit. This is a compound of the sulphates of potash and magnesia with magnesium chloride. In a pure state it would contain, theoretically, 16 per cent. of potash. The pure salt is not found in commerce. It occurs in large, irregular deposits, and as mined it is usually of a reddish color and more or less mixed with common rock salt (of which it contains about 30 per cent.), potassium chloride, gypsum and other impurities. In its crude state it is largely used as a fertilizer, after being crushed and ground. The content of potash in the commercial kainit is about 12.5 per cent., of which more than 1 per cent. is derived from the potassium chloride (muriate of potash present). Most of the kainit mined is sold in its natural state for fertilizing purposes, although a considerable part is used for the manufacture of high-grade sulphate of potash and other concentrated products.

Kainit is a valuable source of potash, but has the disadvantage of being less concentrated than some of the other salts, and consequently costs relatively more because of its freight and handling of so much undesirable matter. For most crops kainit is a valuable source of potash, but on such crops as tobacco it should never be used, as the chlorine which it contains injures its quality. Kainit is generally considered to be particularly valuable on light sand and peat soils, as it has a tendency to keep the soil compact and thus retain moisture. Kainit is considered to have special virtues in preventing some kinds of blight and the ravages of some insects.

Carnallit.

This mineral is the most abundant of the natural deposits of potash. It is a mixture of potassium and magnesium chlorides, and is the chief source of muriate of potash and other concentrated salts. It occurs mixed with rock salt and other minerals in layers averaging about 85 feet in thickness. The color varies and shades through semi-transparent, and white, bright to dark red, yellow and light to dark gray. Commercial carnallit has slightly less potash than kainit, containing about 9 per cent. of actual potash. It is seldom used in its crude state for fertilizing purposes, except in localities near the mines. It absorbs water freely from the atmosphere, and is consequently difficult and disagreeable to handle.

Sylvinit.

Considerable quantities of this mineral have been mined in recent years. It is in the main a mixture of sodium and potassium chloride or rather of a mineral known as sylvine which is a pure potassium chloride and of rock salt which is sodium chloride. It also contains some kainit and other impurities. It contains from 14 to 18 per cent. of actual potash in the form of the chloride (muriate). It is finely ground and used as a fertilizer or is manufactured into concentrated potash salts.

Hartsalz.

This mineral is a mixture of sylvinit and kieserit and is called Hartsalz or hardsalt. It is found in the mines which have been recently opened and seems to take the place of kainit. Hartsalz differs in chemical structure from kainit, but is of almost the same composition and for most purposes is identical with it.

Polyhalite.

This mineral occurs in the Stassfurt deposits and consists of a mixture of potassium, magnesium and calcium sulphates. On account of being practically free from chloride it would be very valuable for fertilizing crops, such as tobacco, which are injured by chlorine; but unfortunately it does not occur in sufficient quantities to become of much commercial importance. It is found only in pockets or seams among the other deposits. It contains about 15 per cent. of actual potash.

Kreugite.

This mineral occurs associated with polyhalite and differs from it in containing about twice as much calcium sulphate (gypsum) and frequently mixed with some common salt. It contains about 10 per cent. actual potash, but has not much commercial importance, at least from a fertilizing standpoint.

Schoenite.

This is a mineral composed of the sulphates of potash and magnesia and contains about 27 per cent. of actual potash. It is specially valuable for fertilizing tobacco and vineyards but on account of the deposits being very limited has not much commercial importance.

Kieserite.

This mineral is really only a magnesium sulphate and does not contain any potash of itself, but as mined has some carnallite mixed with it. In this condition it contains about 7 per cent. actual potash.

Manufactured or Concentrated Potash Salts.

In order to facilitate handling and to save the cost of transportation most of the Stassfurt minerals are purified and concentrated. This also in some instances makes the salts better adapted for fertilizing special crops. The principal manufactured salts sold for fertilizing purposes are the muriate, sulphate and carbonate of potash.

Muriate of Potash.

This is the richest and most soluble of the potash salts. It is also the cheapest source of potash. This is largely due to it being a concentrated article and thus making a relative saving in transportation expenses. One-half its weight is pure potash. Muriate is the principal source of potash employed in commercial fertilizers and is well suited for most agricultural crops. It contains considerable chlorine, about 46 per cent., which substance injures the burning and curing quality of tobacco for which crop sulphate should always be used.

Sulphate of Potash.

This is produced by the purification of some of the potash minerals previously described. This form of potash is preferable on heavy soils, and is particularly well adapted for tobacco on account of the absence of chlorine. Many farmers also prefer sulphate of potash for potatoes, beets, fruits and tender vegetables, as it forms a better quality. Sulphate of potash contains 48 to 50 per cent. actual potash.

Sulphate of Potash and Magnesia.

Doubled Manure Salt.

This is another of the salts produced in the manufacture or preparation of the Stassfurt minerals. It is free from chlorine and thus can be used for the same crops as the sulphate of potash. It is a less concentrated form of potash, containing only about 25 per cent. actual potash.

Calcined Potash or Manure Salt.

This salt is not found extensively in our markets. It is produced by a system of purification and concentration of some of the Stassfurt minerals. It contains 15 to 20 per cent. of actual potash, but otherwise has about the same composition and produces about the same effect upon plants as kainit.

Carbonate of Potash and Magnesia.

This is a form of potash that has been specially prepared with reference to fertilizing tobacco, but is also serviceable for all crops where intensive culture is being practiced, and where it is feared that chlorides and sulphates would be injurious. This compound is a dry powder, which makes it easy to apply or mix with other materials. It contains about 18 per cent. actual potash.

Silicate of Potash.

This is another potash salt that has been especially prepared for tobacco fertilizers. It has not been placed regularly upon the market. The results of experiments conducted so far are not very decisive as to its value. It contains about 21.5 per cent. of actual potash (K20), 19.4 per cent. of which is soluble in water.

The average composition of the German potash salts described in the preceding pages is summarized in the following table:

TABLE IV.

Average Composition of Stassfurt Potash Minerals and Salts.

NAME OF SALTS.		Sulphate of Potash.	Muriate of Potash.	Sulphate of Magnesia.	Chloride of Magnesia.	Chloride of Sodium.	Sulphate of Lime.	Matter insoluble in Water—Per ct.	Water—Per ct.	Calculated to Pure Potash (K_2O).	
In 100 parts are contained:		N_2SO_4 Per ct.	KCl. Per ct.	$MgSO_4$ Per ct.	$MgCl_2$ Per ct.	NaCl. Per ct.	$CaSO_4$ Per ct.			Average Per ct.	Guarant'd Per ct.
A. CRUDE SALTS. (Natural Products.)											
Kainit		21.3	2.0	14.5	12.4	34.6	1.7	0.8	12.7	12.8	12.4
Carnallit		......	15.5	12.1	21.5	22.4	1.9	0.5	26.1	9.8	9.0
Sylvinit		1.5	26.3	2.4	2.6	56.7	2.8	3.2	4.5	17.4	12.4
Polyhalite		28.9	......	19.9	......	......	45.2	......	6.0	14.2	......
Krugite		18.6	......	14.7	.....	1.5	61.0	......	4.2	9.5	......
Schoenite		50.4	......	34.0	......	2.5	......	......	11.0	27.2	......
Keiserite		......	11.8	21.5	17.2	26.7	0.8	......	20.7	7.0	......
B. CONCENTRATED SALTS. (Manufactured Products.)											
Sulphate of potash	96%	97.2	0.3	0.7	0.4	0.2	0.3	0.2	0.7	52.7	51.8
	90%	90.6	1.6	2.7	1.0	1.2	0.4	0.3	2.2	49.9	8.6
Sulphate of potash magnesia		50.4	......	34.0	......	2.5	0.9	0.6	11.6	27.2	5.9
Muriate of potash	90 to 95 %	......	91.7	0.2	0.2	7.1	.....	0.2	0.6	57.7	56.8
	80 to 85 %	.....	83.5	0.4	0.3	14.5	......	0.2	1.1	52.7	50.5
	70 to 75 %	1.7	72.5	0.8	0.6	21.2	0.2	0.5	2.5	46.6	44.1
Manure salt, min. 20% potash		2.0	31.6	10.6	5.3	40.2	2.1	4.0	4.2	21.0	20.0
Manure salt, min. 30% potash		1.2	47.6	9.4	4.8	26.2	2.2	3.5	5.1	30.6	30.0
Carbonate of potash and magnesia		......	.....	......	......	......	......	......	.....	18.0	......
Silicate of potash		......	....	....	....	.....	......	.....	......	21.5	.....

OTHER SOURCES OF POTASH FERTILIZERS.

Every farm produces some materials that contribute more or less to the supply of potash fertilizers—such as stable manure, the straw of cereals and legumes, beet tops, potato vines and tobacco stems; but these, though by-products, are really only agencies for converting soil fertility which the farm already possesses. The only other sources of potash that are of any commercial importance are wood ashes, tobacco stems, cottonseed hull ashes and potash nitrate.

Wood Ashes.

This is practically the only American source of potash that is abundant enough to be of any commercial importance and this supply is now so limited as to restrict their use. Potash in wood ashes is in the most valuable form of the carbonate. Wood ashes, besides furnishing about 5 per cent. potash, also contain one to two per cent. of phosphoric acid and 30 to 35 per cent. of lime, which are also valuable as fertilizers. The quality of ashes varies considerably with the kind of wood used to produce them and the care with which they are preserved. The difference in quality is so great without any change in appearance that the only safe way to purchase is upon guaranteed analysis.

Good wood ashes which have not been exposed to the weather or otherwise wet, such as may be described as house ashes, weigh about forty-eight pounds to the bushel and carry about 8 per cent. potash and 2 per cent. phosphoric acid. Canada unleached wood ashes as sold by the carload are rated at 45 lbs. to the bushel and run from 4 to 6 per cent. of potash and about one per cent. phosphoric acid. Leached or weathered ashes are much less valuable, as they contain only one or two per cent. potash.

Cottonseed Hull Ashes.

These come from the cotton oil factories of the south, where the hulls removed from cottonseed in the process of extracting the oil are afterwards used to some extent for fuel. In recent years much of the cottonseed hulls have been used for cattle food purposes and some has been finely ground and used for adulterating cottonseed meal. This has caused much less to be used for fuel than was the case some years ago, so that the supply of the ash is quite limited. These ashes range from 18 to 30 per cent. of potash and 5 to 10 per cent. phosphoric acid. They are therefore highly soluble for fertilizing purposes and have been much sought by fertilizer manufacturers who keep them so closely bought that they are seldom found on the general market. Cottonseed meal, which is largely used in mixed fertilizers in some sections, supplies some potash as well as nitrogen and phosphoric acid.

Tobacco Stems.

The stems and stalks of tobacco which are waste products in manufactures are rich in potash. It contains from 6 to 7 per cent. of potash and about 2 per cent. nitrogen, with about one-half of one per cent. of phosphoric acid. It thus could really be termed a complete fertilizer in itself. For best results the stems should be finely ground before application. Tobacco stems are also useful for making spraying solutions and for applying to land to prevent insect ravages. They are also used extensively for smoking green house crops to kill insect pests.

Nitrate of Potash.

Nitrate of potash is the true saltpetre of commerce. It is rich in both nitrogen and potash and would be a valuable source of plant food were it not for the fact that its supply is limited and it has many other uses in the arts which cause the price to be too high for fertilizing purposes. This was an important source of both nitrogen and potash before the discovery of the Stassfurt potash salts. Most of the nitrate of potash is found in caves; but in recent years there has been numerous reports of the discovery of extensive deposits in Africa, but up to this time not enough has come on the market to materially change the price.

Miscellaneous Sources of Potash.

There are a few sources of potash that may be available at times and which would be valuable under local conditions, yet they are not of any commercial importance.

Brick-kiln ashes have some value for potash, yet are generally of poor quality as they are produced from soft woods and are much mixed with clay and brick dust.

Lime-kiln ashes are still poorer as a rule in potash, being mostly lime dust.

Coal ashes contain a trace of potash and lime, but are really of no value as a fertilizer except as benefiting some lands by giving them a better mechanical condition.

The Green Sand Marls of New Jersey contain a good deal of potash, sometimes as much as five per cent. The potash is in an insoluble condition and not readily available to plants.

A number of *Maryland Marls* have been examined at this Station, (See Bulletin No. 66) which were found to have from two to four per cent. of potash, although insoluble.

For convenience the composition of the sources of potash, other than the Stassfurt salts, are summarized in the following, Table V.

TABLE V.

Composition of Miscellaneous Sources of Potash.

	Water %	Potash %	Phosphoric acid %	Nitrogen %	Lime %
Nitrate of potash or salt peter	2.0	45.0	....	13.0	....
Wood ashes (unleached)......	12.0	5.5	1.8	....	34
Wood ashes (leached)...........	....	1.1	1.4	....	....
Cottonseed hull ashes	7.0	24.0	7.5	....	10
Tobacco stems....................	10.6	6.4	0.6	2.3	4
Spent tan bark ashes........	6.3	2.0	1.6	....	33
Waste from gunpowder works	2.7	18.0	....	2.4	1
Black residium or ash...........	....	7.4	0.4	....	....
Mixed stable manure............	....	0.6	0.3	0.5	0.7
Hen manure......................	....	0.8	1.5	1.6	0.2
Cow urine..........................	....	0.5	....	0.6	....
Horse urine	....	1.5	....	1.5	....
Hog urine...........................	....	0.1	0.8	0.4	....

EXPERIMENTS CONDUCTED WITH POTASH FERTILIZERS.

Description of Tests and Land.

As has already been stated, the object of the experiments conducted with potash, and which are now about to be discussed, was not simply making a test as to whether a particular piece of land required potash, nor was it for the purpose of determining the limits of profitableness or productive capacity of various applications. The experiments had for their object the studying of some of the underlying principles surrounding the use of potash fertilizers as to their time and method of application, their relation to other plant foods and ingredients which enter into the different sources of supply, and to make a general study of the effect of potash on the quality of the crop.

These experiments were inaugurated in 1897, and up to this time six crops have been removed. The land used for these tests is located north of the Experiment Station buildings and in the same field with the phosphoric acid and nitrogen series of plots. The land is a medium stiff clay loam. Though quite level, it has a pretty good drainage. This piece of land, to all appearances, was fairly uniform in character, yet the yields shown by the nothing plot in these experiments indicated that there was considerable difference. There seemed to be a gradual decrease in natural productiveness from Plot 5 to Plot 26.

The previous cropping of this land, so far as known, was as follows: In 1888 there was a poor stand of grain and weeds. This was plowed down and seeded to wheat in the fall. There was timothy and clover seeded in the wheat. Wheat harvested in 1887 gave about eight and one-half bushels per acre. Grass in 1890–91. In 1892 in corn. Spring of 1893 the corn stubble was harrowed and seeded to crimson clover. This was turned under and seeded to wheat in the fall. Wheat cut in 1894; timothy and clover was seeded in the wheat. In 1895 and 1896 the grass in this field was cut for hay. The sod was plowed in November, 1896, and potash plots laid out the following spring.

The following is the program of the experiments conducted:

TABLE VI.

Program of Potash Experiments.

(Plots one-tenth of one acre each.)

The quantity of material applied was such as to give each plot at the rate of 50 pounds of actual potash per acre.

No.	Kind of Fertilizer.
1.	Kainit, applied just before planting (a).
2.	Kainit: { For spring crops, applied in fall For fall crops, applied in spring } (b).
3.	Muriate of potash, applied as (a).
4.	Muriate of potash, applied as (b).
5.	No potash.
6.	Sulphate of potash and magnesia, double manure salt, applied as (a)
7.	Sulphate of potash and magnesia, double manure salt, applied as (b).
8.	High-grade sulphate of potash, applied as (a).
9.	High grade sulphate of potash, applied as (b).
10	No potash.

11. Carbonate of potash and magnesia.
12. Wood ashes.
13. Cottonseed hull ashes.
14 Nothing.
15. No potash.
16. Muriate of potash and lime. 800 pounds lime per acre (only).
17 Sulphate of potash and lime. 800 pounds lime per acre (only)
18. Muriate of potash and phosphoric acid, sufficient dissolved rock applied to equal the phosphoric acid in wood ashes (only)
19 Muriate of potash. lime (800 pounds lime per acre) and phosphoric acid (sufficient dissolved rock applied to equal the phosphoric acid in wood ashes), (only).
20. Nothing.
21 Wood ashes (only)
22 Stable manure, five tons stable manure per acre (only).
23. Silicate of potash.
24 No potash.
25. No potash.
26 No potash.

GENERAL DIRECTIONS OBSERVED IN CONNECTION WITH THE POTASH EXPERIMENTS.

The plots used for the potash tests was the third tier and next to those now in use for the nitrogen experiments. This series of plots runs parallel with the phosphoric acid and nitrogen series, and are numbered commencing at the end next to the Experiment Station building, numbering northward toward Paint Branch.

Methods of applying. All fertilizers shall be applied broadcast. (a) shall be applied after the ground has been plowed and harrowed once, and then harrowed in immediately before planting the crop. Under (b) for spring crop the potash shall be applied in the spring or summer just after the last crop has been removed from the ground. In case the land is to be plowed several months before planting, apply the potash immediately after plowing; but in case the land is not plowed until just previous to putting in the crop, apply the potash from three to six months before planting time.

To all plots except where the word "only" and "nothing" (Plots 14, 16, 17, 18, 19, 20, 21, 22) are used, phosphoric acid and nitrogen shall be applied whenever deemed necessary. Applying them at same time and with the potash manures, as under (a). All plots receiving the same quantities of phosphoric acid and nitrogen. The quantity of phosphoric acid and nitrogen applied shall be in such a quantity as circumstances shall seem to warrant. All plots to be seeded to crimson clover whenever possible. The quantities of fertilizer applied give all plots the same quantity of potash—K_2O. The preparation of the land, the cultivation of the crop, the variety of seed used, and all other treatments of the plots, were as uniform as was possible to give.

TREATMENT GIVEN PLOTS.

There were a few courses pursued, in connection with the cropping of these plots, that are worthy of special note. In 1897 crimson clover was seeded in the corn at the last working. This gave a good stand and was turned under for the crop of late potatoes.

Previous to planting the potatoes in 1898 there was fifty pounds of dissolved South Carolina rock applied broadcast to plots 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 14 and 15, in addition to the potash indicated by the program. The potatoes were not dug until November 7th, which was too late to seed anything on the land, and it was bare during the winter. The next spring the land was plowed and prepared for cowpeas, which were seeded May 24, 1899. The land was plowed after removing the cowpeas, and seeded to wheat October 5, 1899. There was no fertilizer applied previous to seeding the wheat.

The potash was applied to all plots previous to each crop, which was removed, except the wheat. Phosphoric acid was applied once up to this time, as stated above, to the potato crop of 1898. There has been no nitrogenous fertilizer applied to this time.

RESULTS OF EXPERIMENTS

Time of Application of Potash Fertilizer.

The question of the time of application of commercial fertilizers is one that has been given very little consideration, and there is not much data as to experiments upon this subject. The general rule followed by farmers is to apply all commercial fertilizers just previous to planting the crop. This practice has been adopted not only because of convenience, but also from the fact that it required the shortest period for the money to be invested in the fertilizer.

In connection with the study of the diffusion and fixation of potash salts, it has been decided that it was generally best to apply them several months before planting the crop; particularly was it best to apply in the fall for spring crops. This advice, of course, had to be varied with the character of the soil. On leachy and light soils, of course, there would be less ability of the soil to fix the potash, and hence, if applied long before it was to be used, there would likely be too much loss.

The manufacturers of German potash salts have for a number of years been recommending that muriate of potash be applied to heavy lands in autumn and to light sandy lands in spring. They also recommend that potash salts should always be applied broadcast and plowed down, rather than applied on the surface as a top dressing.

In the experiments conducted at this Station, tests were made with kainit, muriate, sulphate and double manure salt, applying them just before planting the crop and three to six months before. In every case where it was practical, the potash salt was applied after plowing and harrowed into the soil. In some cases the fall applications had to be made as a top dressing.

The results of this test are given in Tables VII, VIII and IX. The results, with one exception, all favor applying fertilizers which contain much chlorides, several months before planting the crop, and those having the potash as sulphate at the time of planting the crop. The crop of cowpeas gave results just the reverse. It is a matter of interest to note that the results obtained give about the same figures favoring applying chlorides a considerable time before planting crop, as was obtained favoring the application of sulphates at time of planting the crop; that is, by excluding the cowpea figures, there was in five crops 3,527 pounds more product obtained by applying chlorine potash salts three to six months before planting crop, and 3,600 pounds more by applying sulphates at time of planting crop.

On soils which contain a certain proportion of sand and clay, and with which the potash salts form a sort of cement or mortar, great care should be taken to apply potash salts only in the fall, so that freezing and thawing can overcome these conditions. Experiments of Brum-Tickle, Jour. Chem. Soc. London, Dec 1902, p. 687, showed the best time to apply potash salts for potatoes was in the winter. On new soils rich in peat more potash could be used than with soils longer in cultivation.

TABLE VII.

Comparison of Different Times of Applying Potash Salts —Grain Crops: Yields per Acre.

Kind of Fertilizer.	Corn—1897.				Wheat—1900.			
	Grain.		Fodder	Total Yield.	Grain.		Straw.	Total Yield.
	Bu.	lbs.	lbs.	lbs.	bu.	lbs.	lbs.	lbs.
Applied Just Before Planting Crop.								
Kainit	68.1	4770	3190	7960	28.3	1700	3500	5200
Muriate of potash	79.9	5590	3490	9080	35.7	2140	5550	7690
Double manure salt	67.4	4720	3130	7850	33.0	1970	3500	5470
Sulphate of potash	74.0	5180	3240	8420	23.3	1400	4450	5850
Average	72.4	5065	3262	8327	30.1	1802	4250	6052
Applied 3 to 6 Months Before Planting.								
Kainit	76.8	5375	3460	8835	34.7	2080	5200	7280
Muriate of potash	76.3	5340	3380	8720	38.0	2270	5550	7820
Double manure salt	63.4	4440	2960	7400	23.1	1390	3500	4890
Sulphate of potash	68.4	4790	3100	7890	23.5	1410	3500	4910
Average	71.2	4986	3230	8211	29.8	1787	4438	6225
Applied Just Before Planting								
Average of chlorine salts	74.0	5180	3340	8520	32.0	1920	4525	6445
Average of sulphate salts.	70.7	4950	3185	8135	28.2	1685	3975	5660
Applied 3 to 6 Months Before Planting.								
Average of chlorine salts	76.6	5357	3420	8777	36.4	2175	5375	7550
Average of sulphate salts	65.9	4615	3030	7645	23.3	1400	3500	4950
Difference in favor of applying chlorine salts 3 to 6 months before planting crop	2.6	177	80	257	4.4	255	850	1105
Difference in favor of applying sulphate salts at time of planting crop	4.8	335	155	490	4.9	285	475	760

TABLE VIII.

Comparison of Different Times of Applying Potash Salts.—Potato Crops: Yields per Acre.

Kind of Fertilizer.	Late Potatoes—1898.				Early Potatoes—1902.			
	Large Size.	Seconds.	Total Yield.	Total Yield.	Large Size.	Seconds.	Total Yield.	Total * Yield.
	Bu	Bu.	Bu.	℔s	Bu.	Bu.	Bu.	℔s.
Applied Just Before Planting Crop.								
Kainit	52.7	12.7	71.0	4260	24.8	20.3	51.0	3060
Muriate of potash	65.0	14.0	84.8	5090	45.0	17.8	66.7	4000
Double manure salt	61.7	15.0	84.7	5080	54.0	31.2	90.0	5400
Sulphate of potash	65.5	18.8	93.5	5610	46.2	25.3	74.7	4490
Average	61.2	15.1	83.5	5010	42.5	23.6	70.6	4236
Applied 3 to 6 Months Before Planting.								
Kainit	61.5	19.3	87.0	5220	38.5	19.8	62.2	3730
Muriate of potash	77.0	13.7	97.0	5820	44.0	24.8	74.9	4495
Double manure salt	44.7	12.5	65.0	3900	55.5	28.5	87.8	5270
Sulphate of potash	58.8	19.3	84.8	5090	33.5	20.3	57.0	3420
Average	60.5	16.2	83.5	5008	42.9	23.4	70.5	4230
Applied Just Before Planting.								
Average of chlorine salts	58.8	13.3	77.9	4675	34.9	19.0	58.8	3530
Average of sulphate salts	63.6	16.9	89.1	5345	50.1	28.2	82.3	4945
Applied 3 to 6 Months Before Planting.								
Average of chlorine salts	69.2	16.5	92.0	5520	41.2	22.3	68.5	4112
Average of sulphate salts	51.7	15.7	74.9	4495	44.5	24.4	72.4	4345
Difference in favor of applying chlorine salts 3 to 6 months before planting crop	10.4	3.2	14.1	845	6.3	3.3	9.7	582
Difference in favor of applying sulphates at time of planting	11.9	1.2	14.2	850	5.6	3.8	9.9	600

* Including culls.

TABLE IX.

Comparison of Different Times of Applying Potash Salts.—Hay Crops, and Summary of All Crops.—Yields per Acre.

Kind of Fertilizer.	1899. Cowpeas ℔s.	1901. Hay. ℔s.	Total Yield of Six Crops. ℔s.
Applied Just Before Planting Crop.			
Kainit	4800	3800	29080
Muriate of potash	5700	4550	36110
Double manure salt	5750	5600	35150
Sulphate of potash	6200	5050	35620
Average	5612	4750	33990
Applied 3 to 6 Months Before Planting Crop.			
Kainit	4800	4400	34440
Muriate of potash	4900	5250	37005
Double manure salt	7700	5150	34310
Sulphate of potash	6750	3700	31760
Average	6037	4625	34379

TABLE IX—Concluded.

Applied Just Before Planting Crop.			
Average of chlorine salts	5250	4175	32595
Average of sulphate salts	5975	5325	35385
Applied 3 to 6 Months Before Planting Crop.			
Average of chlorine salts	4850	4825	35722
Average of sulphate salts	7225	4425	33035
Difference in favor of applying chlorine salts 3 to 6 months before planting crop	(-400)	650	3127
Eliminating cowpea crop	......	......	3527
Difference in favor of applying sulphate salts at time of planting crop	(-1250)	900	2350
Eliminating cowpea crop	......	......	3600

THE EFFECTS OF DIFFERENT POTASH FERTILIZERS ON YIELDS.

German Potash Salts.

In Table X are given the results of the average of the two plots fertilized with different kinds of German potash salts, and in Table XI a summary of those obtained by applying the salts at the most favorable time, as shown by Tables VII, VIII and IX.

None of these results show a very marked increase of product as a result of potash fertilization, yet they do point toward muriate as being the most efficient in producing an increase of crop. Sulphate of potash stands second; carbonate of potash and kainit in these tables indicate negative results.

The effect of potash in increasing crops will vary, of course, considerably with different classes of soils; but the results presented here will probably hold good for a considerable part of the clay soils in this State.

TABLE X.

COMPARISON OF GERMAN POTASH SALTS

(Average of two plots each)

(Yields per Acre.)

Kind of Fertilizer.	Corn—1897.				Wheat—1900.			
	Grain.		Fodder	Total Yield	Grain.		Straw.	Total Yield,
	Bu*	lbs	lbs.	lbs	Bu.	lbs.	lbs	lbs.
Kainit	72.5	5072	3325	8397	31.5	1890	4350	6240
Muriate of potash	78.1	5465	3435	8900	36.7	2205	5550	7755
Sulphate of potash and magnesia (double manure salt	65.4	4 80	3045	7625	28.0	1680	3500	5180
Sulphate of potash (high grade)	71.1	4985	3170	8155	23.4	1405	3975	5380
Carbonate of potash and magnesia	71.6	5010	3340	8350	26.5	1590	4000	5590
Nothing	69.5	4865	3140	8005	27.9	1675	4550	6225

* Allowing 70 lbs. of corn ears to bushel.

Kind of Fertilizer.	Late Potatoes—1898.				Early Potatoes—1902			
	Large Size.	Seconds.	Total* Yield.	Total* Yield.	Large Size	Seconds	Total* Yield.	Total* Yield
	Bu.	Bu.	Bu.	lbs.	Bu.	Bu.	Bu.	lbs.
Kainit	57.0	16.0	79.0	4740	31.7	20.5	56.6	3395
Muriate of potash	71.0	13.8	90.9	5455	44.5	21.3	70.8	4250
Sulphate of potash and magnesia (double manure salt)	53.2	13.8	74.8	4490	54.7	29.8	88.9	5335
Sulphate of potash (high grade)	62.2	19.0	89.2	5350	39.9	22.8	65.9	3995
Carbonate of potash	56.0	19.8	84.8	5090	34.5	21.7	59.5	3570
Nothing	57.8	14.8	80.5	4830	38.5	25.9	69.0	4140

* Including culls.

Kind of Fertilizer.	1899. Cowpeas. lbs.	1901. Hay. lbs.	Total Yield for Six Crops. lbs.
Kainit	4800	4100	31760
Muriate of potash	5300	4900	36557
Sulphate of potash and magnesia	6725	5650	34730
Sulphate of potash (high grade)	6475	4375	33690
Carbonate of potash and magnesia	7450	4000	34050
Nothing	6675	4950	34825

TABLE XI.

COMPARISON OF YIELDS WITH DIFFERENT POTASH SALTS.

(Applied at the season which gave best returns.)

(Yields per Acre.)

Kind of Fertilizer.	1897. Corn. lbs.	1898. Potatoes. lbs.	1899. Cowpeas lbs.	1900. Wheat. lbs.	1901. Hay. lbs.	1902. Potatoes. lbs.	Total. lbs.
Kainit	8830	5220	4800	7280	4400	3730	34440
Muriate of potash	8720	5820	4900	7820	5250	4495	37005
Double manure salt	7850	5080	5750	5470	5600	5400	35150
Sulphate of potash	8420	5610	6200	5850	5050	4490	35620
Nothing (average of 2 plots)	8005	6225	4830	4140	6675	4950	34825

EXPERIMENTS WITH SILICATE OF POTASH.

This is a Stassfurt preparation that has been but recently manufactured, with an idea of using it as a source of potash for tobacco. It has not been placed regularly on the market in this country; nevertheless it was thought that it might be interesting to test it in comparison with other sources of potash. The potash plots being a little uneven, it was not thought quite fair to compare this with the other German salts.

In Table XII will be found the results of the use of silicate of potash, and wood ashes are also given, as this was the only other source of potash which contained any considerable quantity of potash insoluble in water. It will be noticed that the silicate produced a marked increase in yield with all crops, though not quite as great as the wood ashes plot which was beside it. Potatoes and grass seemed to have the greatest relative ability to feed upon the silicate.

EXPERIMENTS WITH WOOD ASHES AND STABLE MANURE.

In Table XII will be found the yields produced by an application of stable manure and wood ashes. These results show that the stable manure was particularly efficient in increasing yield, which would seem to indicate that this land was lacking in a physical character which the organic matter can produce to better advantage than the caustic principle of the wood ashes.

TABLE XII.

Results of the Use of Silicate of Potash and Stable Manure.
(Yields per Acre.)

Kind of Fertilizer.	Corn—1897				Wheat—1900.			
	Grain.		Fodder	Total Yield.	Grain.		Straw.	Total Yield.
	Bu.	lbs.	lbs.	lbs.	Bu.	lbs.	lbs.	lbs.
Nothing (average of plots 20, 24, 25, 26)	54.1	3790	2780	6570	22.9	1370	3162	4532
Silicate of potash	58.4	4090	2770	6860	25.0	1480	3900	5380
Wood ashes	66.3	4640	3530	8170	28.0	1680	4000	5680
Stable manure	78.9	5520	2770	8290	37.0	2220	5350	7570

Kind of Fertilizer.	Late Potatoes—1898.				Early Potatoes—1902.			
	Large Size.	Seconds	Total* Yield.	Total* Yield.	Large Size.	Seconds.	Total* Yield.	Total* Yield.
	Bu.	Bu.	Bu.	lbs.	Bu.	Bu.	Bu.	lbs.
Nothing (average of plots 20, 24, 25, 26)	22.5	15.9	48.1	2887	19.9	10.7	37.1	2225
Silicate of potash	44.2	15.7	69.0	4140	29.3	13.2	47.5	2850
Wood ashes	49.7	14.5	72.3	4340	40.8	14.2	61.3	3680
Stable manure	58.3	18.8	86.5	5190	47.0	18.2	70.8	4250

Kind of Fertilizer.	1899. Cowpeas lbs.	1901. Hay. lbs.	Total * for Six Crops. lbs.
Nothing	5050	2862	24152
Silicate of potash	5400	4500	29130
Wood ashes	6500	4750	33130
Stable manure	5350	5200	35850

* Including culls.

TESTS OF DIFFERENT SOURCES OF CARBONATE OF POTASH.

In Table XIII are given the results of the use of the different sources of carbonate of potash which are available for fertilizing purposes.

The results show that all the forms were quite effective in increasing the yields Cottonseed hull ashes proved the most effective, but, as has been previously stated, this supply is quite limited and does not come into the general market. The carbonate of potash and magnesia, which is one of the Stassfurt productions, did not seem quite as active at the start, but with the six crops it produced a larger increase than wood ashes. This result is particularly interesting, as the supply of wood ashes, which is so highly prized, is becoming scarcer each year; and consequently, if the carbonate of potash and magnesia can be placed on the market at a reasonable price, it may be able to supply many with a carbonate of potash who now cannot get wood ashes. It will be noted that the carbonate of potash and magnesia produced on the six crops over double as much increase as was produced by the muriate of potash when compared to their respective nothing plots.

TABLE XIII.

Comparison of Different Sources of Carbonate of Potash.
(Yields per Acre.)

Kind of Fertilizer.	Corn—1897.				Wheat—1900.			
	Grain.		Fodder	Total Yield.	Grain.		Straw.	Total Yield.
	Bu.	℔s.	℔s.	℔s.	Bu.	℔s.	℔s.	℔s.
Carbonate of potash and magnesia	71.6	5010	3340	8350	23.5	1590	4000	5590
Wood ashes	75.7	5300	3360	8660	26.1	1570	3950	5520
Cottonseed hull ashes	74.0	5180	3450	8630	30.8	1850	4800	6650
Nothing (average of plots 10 and 14)	68.2	4775	3030	7805	19.0	1135	3325	4460

Kind of Fertilizer.	Late Potatoes—1898.				Early Potatoes—1902.			
	Large Size.	Seconds	Total* Yield.	Total* Yield.	Large Size	Seconds.	Total* Yield.	Total Yield.
	Bu.	Bu.	Bu.	℔s.	Bu	Bu.	Bu.	℔s.
Carbonate of potash and magnesia	56.0	19.8	84.8	5090	34.5	21.7	59.5	3570
Wood ashes	50.0	17.0	74.8	4490	31.3	21.1	57.3	3440
Cottonseed hull ashes	65.3	19.3	95.8	5750	46.3	14.5	66.6	3995
Nothing (average of plots 10 and 14)	41.2	14.3	64.7	3880	28.7	17.3	50.1	3010

Kind of Fertilizer.	1899. Cowpeas. ℔s.	1901. Hay. ℔s.	Total Yield for Six Crops. ℔s.
Carbonate of potash and magnesia	7450	4000	34050
Wood ashes	5850	4230	32190
Cottonseed hull ashes	7600	3800	36425
Nothing (average of plots 10 and 14)	4925	3675	27755

* Including culls.

TESTING THE USE OF LIME AND POTASH IN COMBIATION.

It has already been pointed out that lime is valuable in rendering potash available which is already in the soil, by producing the conditions favorable for the formation of double silicates. Lime performs this same function in connection with potash salts which are applied to soils.

In certain soils potash, as well as other salts, such as salt and nitrate of soda, produce a marked physical change by cementing or hardening the soil. This interferes with the circulation of the air and moisture, and with the distribution of the rootlets of crops. This unfavorable condition is partially due to the hygroscopic nature of the salts. On soils of this nature lime has the power to counteract these harmful results; therefore should always be applied in conjunction with potash salts.

Again, it must not be forgotten that the addition of potash salts to the soil has a tendency to cause a loss of lime, from the fact that in the mutual reactions which take place in the soil, alkaline silicates are formed from the sulphates and chlorides, and a quantity of lime corresponding to those is converted into sulphates and chlorides. These lime salts are subject to loss by washing and leaching—particularly is this true of the chlorides. Hence this condition is more likely to follow the use of kainit and muriate of potash. By experiment it has been shown that 100 pounds of kainit to a soil may cause a loss of 40 parts of lime.

Experiments conducted by the Massachusetts Station have shown that if muriate of potash is used without proper precaution on soils with a limited supply of lime, the full benefit of the potash would not be obtained, because the lime of the soil was converted into a soluble form which was either washed out in the drainage or it accumulated in the upper soil and poisoned the plants. It was observed that oats, rye and soja beans grown on soil which had received applications of muriate of potash for a number of years in succession, continued to decrease in yield and were unhealthy in appearance. This condition was attributed to the action of the muriate on the lime of the soil, and an examination of the drainage water of the soil showed a considerable quantity of chloride of lime and much more than where sulphate of potash was used. On soils that have a good drainage, liberal applications of lime will overcome any harmful effects of the above nature attending the application of muriates, but in soils that are not well drained it would be best to depend upon some other source of potash.

With the idea of studying the desirability of the use of lime with potash salts, some combined applications were made in the series of experiments conducted at this Station. These tests were also conducted with an idea that they might throw some light upon whether wood ashes were chiefly valuable for the potash or the lime which they furnished. The results of the tests made in this connection are given in Table XIV.

Comparing the results given in Table XIV with those given in Table X, it will be seen that on this soil the use of lime with muriate and sulphate did not prove of any material advantage.

The results given in Table XIV show that the use of lime with sulphate of potash was more effective in increasing yields than wood ashes, while the muriate of potash and lime was less so. Supplementing muriate with phosphoric acid, and with lime and phosphate in combination, gave rather negative results—at least nothing that satisfactory conclusions could be drawn from.

These tests may show out more marked with a continuance of the experiments as the point for need of lime may be arrived at.

TABLE XIV.

Showing the Results of Using Lime and Phosphoric Acid in Combination with Potash Salts.

(Yields per Acre.)

Kind of Fertilizer.	Corn—1897.				Wheat—1900.			
	Grain.		Fodder	Total Yield.	Grain.		Straw.	Total Yield.
	Bu.	lbs.	lbs.	lbs.	Bu.	lbs	lbs.	lbs.
Nothing (average of plots 14, 15 and 20)	65.0	4547	3090	7637	21.7	1298	3600	4898
Wood ashes (average of plots 12 and 21)	71.0	4970	3445	8415	27.0	1625	3975	5600
Muriate of potash and lime	69.9	4890	3200	8090	21.0	1240	3500	4740
Sulphate of potash and lime	75.0	5250	3320	8570	23.3	1400	4000	5400
Muriate of potash and phosphoric acid	70.3	4920	3060	7980	27.0	1610	4050	5660
Muriate, lime and phosphoric acid	65.9	4610	2530	7140	27.0	1620	4050	5670

Kind of Fertilizer.	Late Potatoes—1898.				Early Potatoes—1902.			
	Large Size.	Seconds.	Total * Yield	Total * Yield.	Large Size.	Seconds.	Total * Yield.	Total * Yield.
	Bu.	Bu.	Bu.	lbs.	Bu.	Bu.	Bu.	lbs.
Nothing	39.7	14.9	64.1	3847	29.7	12.9	46.7	2800
Wood ashes	49.9	15.7	73.5	4415	36.0	17.2	59.3	3560
Muriate of potash and lime	49.3	17.7	91.7	5500	19.0	14.0	38.3	2300
Sulphate of potash and lime	43.3	18.2	71.8	4310	26.7	12.8	45.3	2720
Muriate of potash and phosphoric acid	40.8	17.0	69.0	4140	32.3	14.2	53.3	3200
Muriate, lime and phosphoric acid	39.2	18.2	67.8	4060	12.8	12.8	31.0	1860

Name of Fertilizer.	1899. Cowpeas. lbs.	1901. Hay. lbs.	Total Yield for Six Crops. lbs.
Nothing	5600	3600	28380
Wood ashes	6175	4490	32660
Muriate of potash and lime	5900	4250	30830
Sulphate of potash and lime	8050	6050	35100
Muriate of potash and phosphoric acid	5600	5200	31780
Muriate, lime and phosphoric acid	5500	5150	29380

*Including culls.

CONDITIONS INFLUENCING THE EFFECTIVENESS OF POTASH.

The experiments reported upon in this Bulletin, as well as the results of those of the phosphoric acid and nitrogen series of plots which are parallel to the potash series and on about the same character of land, show quite clearly that this soil is not as deficient in potash as it is in phosphoric acid. It is also evident that the soil lacks organic matter and nitrogen.

These facts show that for marked results in increased yields with potash the ration of plant foods should be balanced, and the soil should also be put in a better mechanical condition. These conditions were recognized, in a measure, from the beginning of the tests, but it was not deemed desirable to provide them at the start. However, this part of the work will be given due attention in the continuation of these studies.

THE RELATION OF POTASH FERTILIZERS TO QUALITY OF CROP.

In the experiments reported upon in the preceding pages, it was not possible to observe any special effect of the fertilizers used upon the quality of the product; but this Station made extensive experiments upon the effect of potash fertilizers upon tobacco, the results of which are reported in Bulletin No. 26, and upon tomatoes, and reported in Bulletin No. 11. It was shown that high-grade sulphate of potash produced the best tobacco, and carbonate of potash, as furnished by cottonseed hull ashes, the next best. All potash salts which contained either much chlorine or magnesia produced a tobacco of poor quality, which cured badly and a very poor burning quality.

In the tomato experiments, potash had a marked effect in increasing the yield and quality of the tomatoes. Tomatoes fertilized with potash were more solid, yet a little more acid.

NOTES ON THE EFFECT OF POTASH ON QUALITY, BY OTHER STATIONS.

The Kentucky Station Bulletin, No. 22, p. 16, notes that sulphate of potash produced not only a large yield, but also a dryer and larger and smoother potato than any other salt.

Experiments by the Kentucky Station, Bulletin 28, p. 13, showed that, while sulphate and muriate had about the same effect in increasing the yield of tobacco, sulphate gave best quality. Kentucky Bulletin 27 states that sulphate and muriate produced about the same effect on hemp.

Kentucky Bulletin 45 states that the effect of potash fertilizers showed four seasons after application.

Massachusetts Station Annual Report, 1893, p. 155, states that their tests gave results decidedly in favor of sulphate both for yield and quality.

Experiments conducted by both the Massachusetts and New Hampshire Stations proved that the average mixed fertilizer contained too little potash for general farm crops on New England soils, and that muriate of potash was decidedly unfavorable to starch formation in potatoes.

Experiments conducted by the Massachusetts Station, Bulletin 15, p. 7, on carnations, roses and lettuce, proved that sulphate was much superior to muriate for these crops. It gave more and better bloom, and the plants were freer from mildew.

It has been observed by some growers that potash has a tendency to produce a higher color in fruit and sometimes in flowers.

Experiments conducted by Pfeiffer, Lemmermann and Schillbach (Landw. versuchs, Stat. 1897, p. 349–385) on the effects of different potash salts on the composition of potatoes, found that chloride of potash and sulphate of potash had about the same effect on the growth and composition of potatoes, while the same amount of potash in the crude salts, containing much chlorides, caused a slight decrease in the amount of starch produced. This was attributed to the magnesium and other chlorides in the crude salts. A low percentage of chlorine in the soil seemed a disadvantage to the growth of potatoes. Unusually high content of starch was sometimes accompanied by a high content of chlorine in the tubers and vines.

INJURIOUS EFFECTS OF POTASH SALTS.

From what has already been said, it is evident that applications of potash are sometimes harmful, at least affect crops unfavorably. The cause of this injury seems to reside chiefly in the chlorides which many of the crude potash salts contain. The harmful results are sometimes manifested by decreasing the yield, but more generally by a deterioration in quality of the product. For instance, when tobacco is fertilized with crude potash salts, muriate of potash or any salt containing considerable chlorine, the burning qualities are considerably impaired. This seems to be due to the fact that the tobacco plant will take up an excess of chlorine and prevent the leaf from burning because of the easy fusibility of chlorine.

An excess of chlorine has also been found to lessen the sugar content of grapes and the starch content of potatoes, and sometimes the sugar content of sugar beets.

Other injurious influences in the use of potash salts which occur under some conditions have already been pointed out, such as the causing the supply of lime to be decreased and producing an undesirable physical condition of the soil.

MISCELLANEOUS INDIRECT EFFECTS OF POTASH SALTS.

Besides the value of potash salts by acting as a direct food for plants, there are a number of advantages attending their application which are worthy of notice, and which may be termed indirect effects.

EFFECT ON NITRIFYING ORGANISMS.

Under some circumstances, the application of large quantities of potash has a tendency to retard the process of nitrification; but experiments conducted by F. D. Chester, Bulletin No. 98, p. 57, Pennsylvania Department of Agriculture, the author claims that the action of potash salts is to combine with the humates of the soil and form compounds which are readily nitrifiable. Dumont found that potash salts alone or mixed with carbonate of lime increased nitrification in soils rich in humus. It has also been shown that nitrifying organisms cannot multiply except there is present, among other elements, lime, phosphoric acid and potash. Nitrification is accordingly aided by the application of mineral fertilizers. These facts seem to add force to the requirements already stated, that there should always be an abundance of lime and vegetable matter in soils which are liberally fertilized with potash.

FOR PRESERVATION OF MANURE.

All kinds of animal manure, when exposed to the elements without care, undergo a more or less rapid decomposition which is attended by a considerable loss of organic matter. In the decomposition of the organic matter there is not only a loss of a considerable amount of humus-forming material, but also of nitrogen. It has been estimated that, as manure is commonly cared for, the loss amounts to one ton of organic matter, and is equivalent to the nitrogen contained in 200 pounds of nitrate of soda, per year per horse.

It has been found that potash salts, particularly kainit, have the property of absorbing and retaining most of the nitrogen, and also preventing harmful fermentation and loss of organic matter. For this purpose the kainit is sprinkled daily in the stable at the rate of one and one-half to two pounds per full-grown animal. This process produces not only the above-named advantages, but also enriches the manure in potash and makes it more nearly a balanced plant food.

Plaster, dissolved phosphates and earth are also valuable for preserving manure.

Part of the value of kainit as a preserver of manure no doubt rests in its germicidal properties when in the concentrated form, but when the manure is spread over the land and diluted and aerated, the activity of the ferments seems to be restored and inaugurated. This is particularly true on light sandy soils.

EFFECTS ON THE CONSERVATION OF SOIL MOISTURE.

Potash salts, through their hygroscopic nature, have the ability to keep soils moist in dry seasons. Dr. H. W. Wiley (U. S. Dept. Agrl. reports) gives the results of some determinations on the moisture content in two samples from the same soil, one with and one without the application of potash. The results were as follows:

Time.	With Kainit. Moisture, %.	Without Kainit. Moisture, %.
March 18th	15.3	15.2
June 1st	8.5	1.8
August 1st	5.0	1.3
October 18th	13.3	1.9

Dr. Wiley remarks on this as follows: "From the above table the marked difference in the moisture in the samples during the summer and autumn is quite instructive. It is true that a soil impregnated with kainit would give up its moisture less rapidly to a growing plant than one free of that salt, but there is no doubt that a soil containing, 13 per cent. moisture, would be able to supply water to a plant more readily than a soil free of it and containing only 2 per cent. of moisture."

There is, however, another phase of the question, and that is that the soil water where the kainit was applied may be so charged with soluble salts that it would be detrimental or in a sense poisonous to the plant and thus cause a crop to suffer more from this cause than it would from lack of water. The writer has observed this condition on two or three occasions with crops on the Station farm.

Potash salts have been found to influence the upward movement of water in the soil. King (Wisconsin Experiment Station Report, 1893, p. 99) states that .08 per cent. nitrate of potash in a sandy soil increased the upward movement of water 22 per cent.

PROTECTION AGAINST FROST.

The presence of a considerable quantity of potash salts in the soil, and their faculty of holding moisture, will have a tendency to retard evaporation of moisture from the soil and thus often either entirely prevent a frost or at least make it lighter than it would otherwise have been.

POTASH SALTS AS INSECTICIDES AND FUNGICIDES.

It has frequently been observed that potash salts will prevent the ravages of insects, and also either prevent or lessen the effects of some plant diseases.

Kainit has given better results for these purposes than any other potash salt. Its greatest usefulness in this character, as far as observed, has been with pests that live in the ground and around the roots of plants, such as root-lice, wire-worms and cut-worms.

Dr. J. B. Smith, entomologist, gives in the bulletins and reports of the New Jersey Experiment Station the results of numerous experiments and observations showing beneficial effects of the use of kainit in preventing root-louse on corn, cut-worm and wire-worm on corn, wire-worm on potatoes, black aphis on the roots of peach trees, and cabbage maggots. He has also found it useful in preventing the breeding of the rose-chafer.

Atkinson in Alabama, Dabney in North Carolina, Parnell in Texas, have all made experiments showing the value of applications of kainit in controlling cotton blight, cotton rust and cotton root rust. Hilgard has found that potash fertilizers will aid in mitigating the effects of the phylloxera on the grape. Numerous observations have been recorded as to the value of potash in overcoming certain yellow conditions or appearances of the leaves of peach trees and bring them back to a healthy, productive condition again. This, however, is not the true "yellows" of the peach. Where the kainit or other potash salt is used for the purpose of its insecticide or fungicide properties, it is necessary to apply it much heavier than would be necessary for simple fertilizing purposes, unless, as is sometimes the case, that very small applications in the hill or drill will give the desired protection.

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